GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

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STATE GEOLOGIST,

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NEW BRUNSWICK, December 23d, 1884.

To His Excellency Leon Abbett, Governor of the State of New Jersey, and ex officio President of the Board of Managers of the State Geological Survey:

SIR—I have the honor herewith to submit my annual report as State Geologist for the year 1884.

With high respect,

Your obedient servant,

GEO. H. COOK,

State Geologist.

REPORT.

In accordance with the spirit of the laws which instituted and have sustained the Geological Survey of New Jersey, its work continues to be the development of her natural resources. Whatever will tend to explain its geological structure, materials or history, may be the subject of its investigations, whatever will turn its products to practical use may be the subjects of its descriptions, whatever will help to make these natural resources known to and understood by the great body of our people, comes within its bounds. Each year brings out new, interesting and profitable truths. The State is advancing in population and wealth, and in its control of the signal advantages of location, of soil and of climate which it possesses.

The work of this year has been devoted to the survey for and construction of good *topographical* and *geological maps*, to the investigation of some of the intricate problems in our *structural geology*, and to questions of drainage, water-supply and other topics connected with *economical geology*.

These several points will be reported on under the following heads, viz.:

I. Geodetic Survey.
II. Topographic Survey.
III. Recent Formations.
IV. Glacial Drift and Yellow Sand and Gravel.
V. Tertiary and Cretaceous Formations.
VI. Triassic Rocks.
VII. Devonian and Silurian Rocks.
VIII. Archaean Rocks.
IX. Iron Mines and Mining Industry.
X. Drainage.
XI. Water-Supply.
XII. Statistics of Iron and Zinc Ores.
XIII. Publications.
XIV. Expenses.
XV. Persons Employed.
XVI. Work to be Done.

I.

GEODETIC SURVEY.

The basis of all accurate maps of large districts of country must be from careful geodetic surveys. The United States is fortunate in having such a survey in full and active operation. The best methods of work which are known are practiced; the best instruments known to science are in use, and competent and skillful men are engaged, with all necessary time to complete accurate observations and computations. New Jersey, by her location on the ocean side, has necessarily been the field for the Coast Survey work along the shores of the Atlantic, and Delaware bay and river, as well as of the Hudson. The act of Congress further provides that the United States Coast and Geodetic Survey shall assist States which are conducting geological or topographical surveys, by furnishing them with accurately determined geographical positions. Under this authority the Coast Survey has been engaged for several years in determining such positions by a system of triangles which are now extended so as to cover nearly all the State. The only part remaining unfinished is in the interior of the southern part.

Prof. Edward A. Bowser is the assistant in charge of this work. During the season just closed he has occupied and completed his observations at the primary stations Mount Holly (24), Apple-Pie Hill (28), and Berlin (40). Observations have also been completed from these primaries upon the tertiary stations West Plains, Spring Hill, Bear Swamp, Jemima Mount, Batsto, Hammonton Church, Indian Mills and Atco.

The reconnoissance has also been made for establishing primary stations at Martha (42), Hammonton (41), Blangie Place (45), Russia (47), Richland (44), Kellogg (57), Newfield (46), Williamstown (43), Five Points (48), Whig Lane (49), and Monroe (50).

The location of these stations can be seen on the accompanying small geodetic and topographic map of New Jersey. The primary stations are all numbered. Those at which the angles have been measured are marked by small triangles, those which are still to be measured are marked by small circles.

If appropriations are made for continuing the work steadily, and with proper assistance and supplies, it may reasonably be expected that the necessary geodetic points for the basis of the map of the entire State can be completed in two years more.

II.

TOPOGRAPHICAL SURVEY.

The State Topographical Survey has been prosecuted steadily during the entire year. Mr. Vermeule has continued in charge of the work, and has been assisted by two, and a part of the year by three leveling parties—and by two, and a portion of the season by three surveyors with the compass and odometer. The parties are still in the field at the date of this report, hoping to be able to close the surveys of some districts which are nearly ended. But they will undoubtedly be obliged to come in before Christmas. The winter will then be devoted to putting the notes they have made in the form of maps. And this is fully sufficient to keep them occupied till the time for field work comes round again.

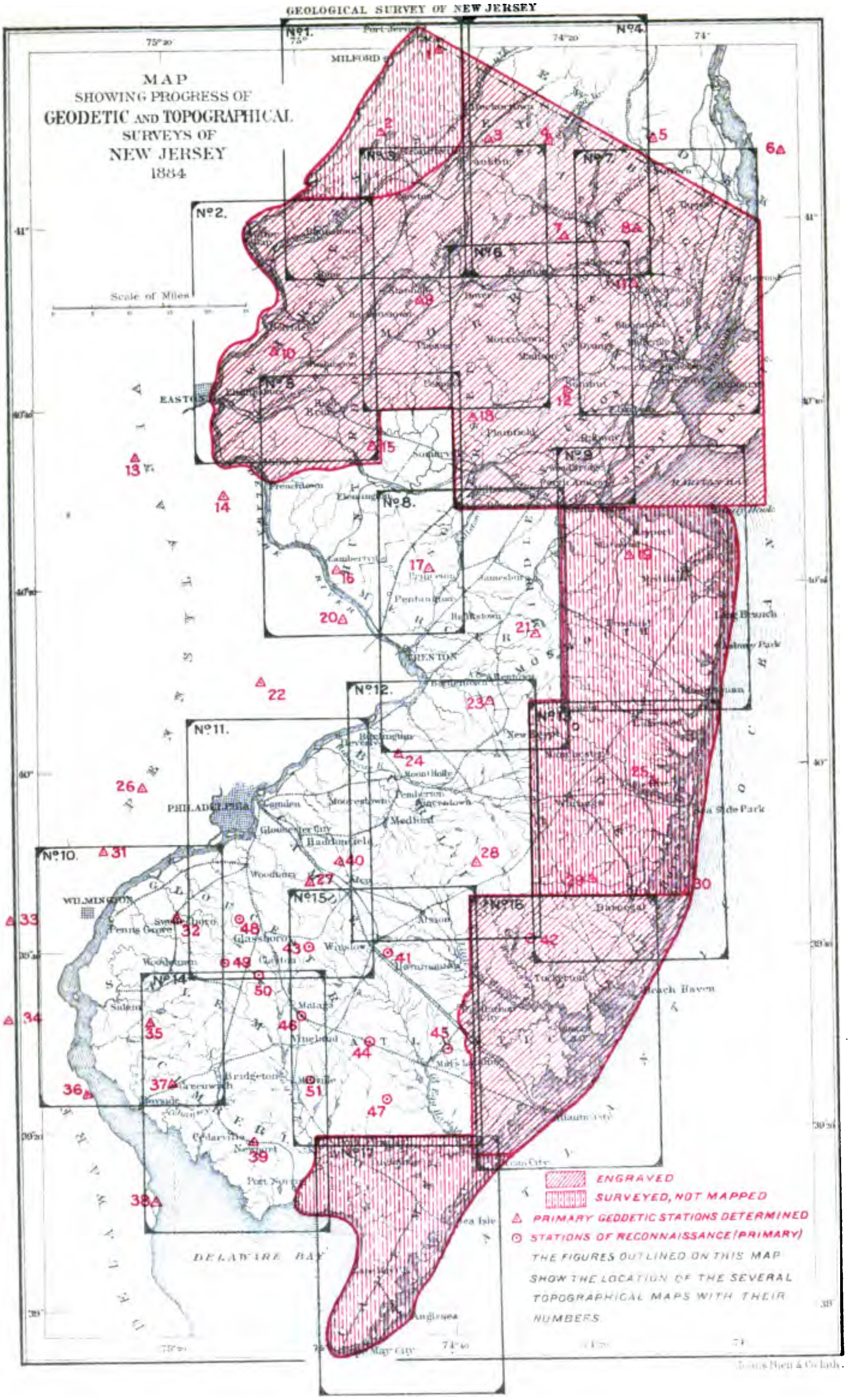
At the close of the last year Mr. Vermeule reported that the total area surveyed was 2,856 square miles. This season's work will include the survey of 1,582 square miles, making the whole area surveyed 4,438 square miles. As the whole State is estimated to contain 7,576 square miles, it may be said that the topographical survey is now completed over three-fifths of its area. The ground which has been gone over is by far the roughest and most difficult part of the State to survey.

"The work done during the past year includes a detailed survey with transit and stadia of 35 lineal miles of the Delaware river, and 70 square miles of the salt marshes and beaches of Cape May county, with their many bays and tortuous creeks and thoroughfares, a work which consumed much time and labor. Thirteen points were determined by tertiary triangulation.

"The area surveyed includes the western half of Sussex, all of Monmouth excepting Millstone and Upper Freehold townships; nearly all of Ocean, all of Cape May, and a portion of Cumberland counties."

The mapping of the surveys has followed close upon the field work.

GEOLOGICAL SURVEY OF NEW JERSEY



At the end of last year Mr. Vermeule reported that 1,893 square miles had been mapped, and 1,691 square miles were engraved and ready for printing. At this time he reports that 2,910 square miles are mapped and are now engraved and ready for printing. Of this area engraved, 1,219 square miles, has been completed since the date of the last report.

In preparing the maps for publication, it has been concluded to have them all on a scale of one inch to a mile, which is 1 to 63,560, and to have them all of the same size, and as large as they can be conveniently printed on a single sheet of paper. After a number of trials to ascertain what would best fit the irregular shape of the State, and the geological belts which cross it obliquely, having regard also to the location of important centers of population and business, the plan shown on the accompanying small map of the State was adopted.

The entire State requires 17 sheets to cover it. Each sheet is 24x34 inches in size. At first view it will be thought that they overlap each other and require an extra amount of engraving. The overlapping is not more than enough to give room for titles to the maps, and the engraving is not increased, as the printing is not done from the engraved stones directly, but from transfers which can be joined together in any way that may be required.

The numbering of the maps is generally from the north towards the south, and they are arranged so that those covering the same geological formation can be easily grouped together, thus:

Nos. 1, 2, 3 and 4 cover all the Archaean and Paleozoic rocks.

Nos. 2, 3 and 4 cover all the Archaean rocks and all the iron ore district of the State.

Nos. 5, 6, 7 and 8 cover the red sandstone formations.

Nos. 8 and 9, with 10, 11 and 12, cover the clay and marl districts of the State.

Nos. 9, 13, 16 and 17 cover the entire Atlantic shore.

The sheets can be taken separately or the whole together. The maps are all drawn on the same system of projection so that any two adjoining ones can be cut, fitted accurately to each other, and made into a single map, or they can be folded across and put in an atlas of 17x24 inches. These, with a map of the whole State, on a scale of five miles to an inch, and which will go on the same sized sheet with the others, will make a complete atlas of New Jersey.

The contour lines are drawn on these maps so as to show every rise of 20 feet elevation in the hilly portions of the State, and every 10 feet in the more level portions. They furnish the data from which important public undertakings for drainage, for water-supply, for the location of roads, railroads, selection of routes of travel, sites for buildings, &c., may be intelligently studied out. Already they have found important uses in forwarding public improvements, and they will be indispensable for every citizen who is interested in public improvements.

The United States Geological Survey, Major J. W. Powell, director, is engaged in preparing a topographical and geological map of the United States. Work is being done for this purpose, by it, in Virginia, North Carolina, Kentucky and Tennessee, and to some extent in several of the other States. In Massachusetts the legislature has joined with the United States Geological Survey in making a detailed topographical survey and map of that State on about the same scale as ours in New Jersey, each of the parties paying one-half of the expense. In our State, where the survey had at that time already extended over about half its area, the United States Geological Survey proposed to pay the further expenses for completing the field work and mapping of the remainder of the State; they being allowed to take copies of the maps which were already completed, and we being allowed to make copies of the remainder of the maps, which are to be prepared at their expense. They proposed also to take into their employment the same persons who had been up to that time engaged in our survey. They only asked that we allow them the use of our instruments for carrying on the work. This arrangement, being plainly advantageous to both parties, was entered upon on July 15th, 1884, and is working satisfactorily. It relieves the funds of the State Geological Survey from the burden of expense involved in carrying on the topographical survey, and will enable it to follow up in detail the work for which the topographical maps furnish the necessary basis.

III.
RECENT FORMATIONS.

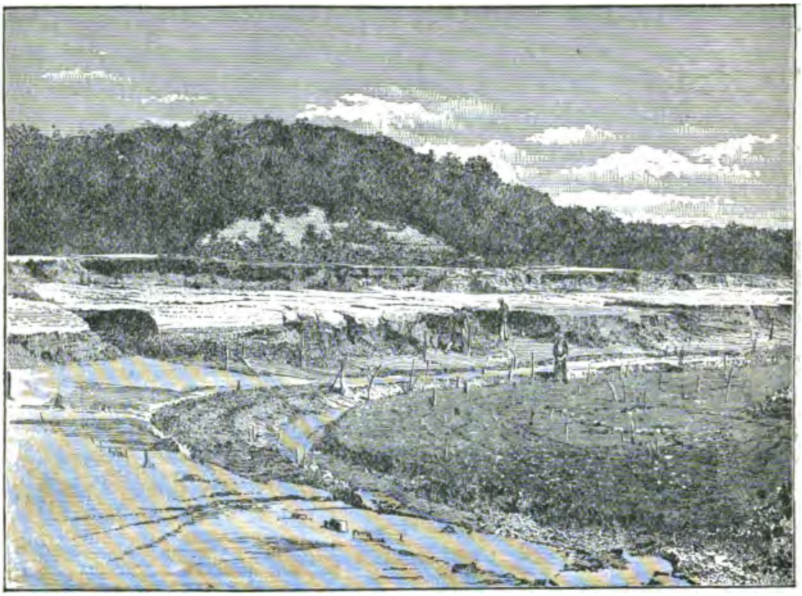
A BURIED FOREST.

At the clay-pits of Otto Ernst, near South Amboy, a curious development and exhibition of recent geological changes has been made. The clay-pits and mines of Mr. Ernst are opened at the bottom and on the lower part of the south slope of the high ground between the Raritan and Chesquake creek. In an interval between two points of higher ground which project out in the marsh and nearly to the creek, is a plot of 10 or 12 acres of nearly level ground, which is, in its highest parts, about 14 feet above the tide-mark. This plot, until the past season, was in forest of chestnut, oak and other common timber, of which some of the largest trees were a foot and a-half in diameter. In the progress of his work Mr. Ernst has cut off the wood from this plot and opened down into it 14 feet or more. For about 12 feet down he found only stratified sand with a little gravel in some of its layers, but at that depth he came upon a buried swamp of white cedar. The trees were small, only a few inches in diameter and still standing, with the bark and wood in complete preservation, as if they had only been buried a few years. The roots were still sound and were imbedded in swamp earth, such as white cedars grow in. But the level of this swamp was 2 feet lower than the adjoining marsh and the common spring tides.

A still more remarkable feature in this development was the discovery of à log of oak, perhaps 14 inches in diameter, 8 or 10 feet long, trimmed and lying in the sand and gravel, about 5 feet under the surface. This tree had been cut down with an axe, apparently, when the earth had filled up around the base of the tree to the depth of 5 or 6 feet; the stump being still standing on ground which was a little higher than the surface of the swamp. Other and larger stumps were also uncovered at the very bottom of the cedar swamp earth.

There is no known record or tradition when this forest was buried. It must have been since the settlement of the country, and cannot, at most, have been more than 280 years, and is probably much more recent than that. It is a remarkable instance of geological change since the country has been inhabited by white men. The little swamp occupies ground which had been covered with heavy forest timber before the cedars grew. The advance of the tides has first held back the fresh water so as to kill the forest trees and allow a swamp to form for the growth of the cedars. Since that time violent rain-storms, with torrents of water, have cut gullies in the adjacent high grounds and carried the loosened earth forward and deposited it where it now lies. All this occurred so long ago that a forest has grown and been cut off from the new surface.

FIG. 1.



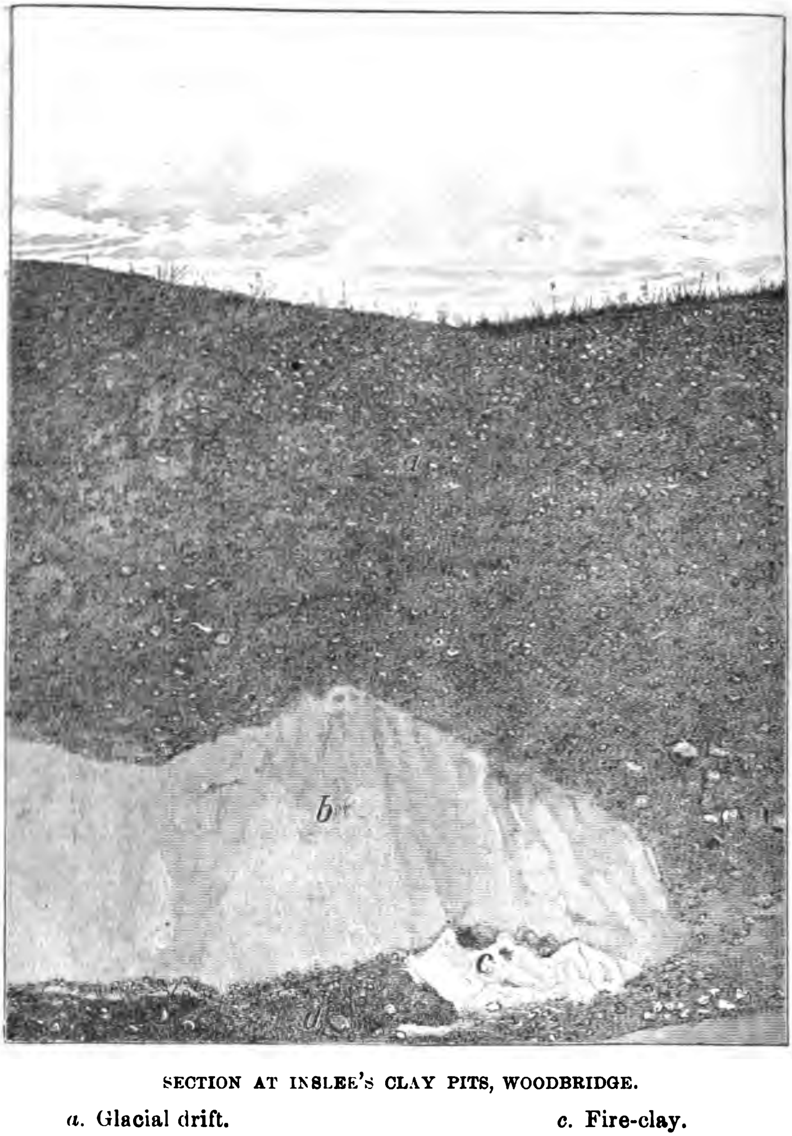
BURIED FOREST AT ERNST'S CLAY PITS, SOUTH AMBOY.

The whole appearance of the ground about the location is such that these recent changes would not be expected; and we have thought it worthy of a place in the report, and of the photograph which is here inserted.

The place is well worth a visit. The opportunity to see such remarkable changes in our own times is rarely so well shown as it is here.

The underlying stoneware clay; the old forest in this soil on the clay; then the black cedar-swamp earth and its embedded small trees, and then the overlying plain of sand and gravel, with its later growth of upland timber, are all to be seen in this single locality, and with them there is the evidence that the ground which was formerly enough above the level of the sea to sustain a growth of upland timber, is now so low that every high tide could cover it with salt water.

FIG. 2.



SECTION AT INSLEE'S CLAY PITS, WOODBRIDGE.

a. Glacial drift.
b. Yellow sand.
c. Fire-clay.
d. Loose debris.

IV.

GLACIAL DRIFT, AND YELLOW SAND, AND GRAVEL.

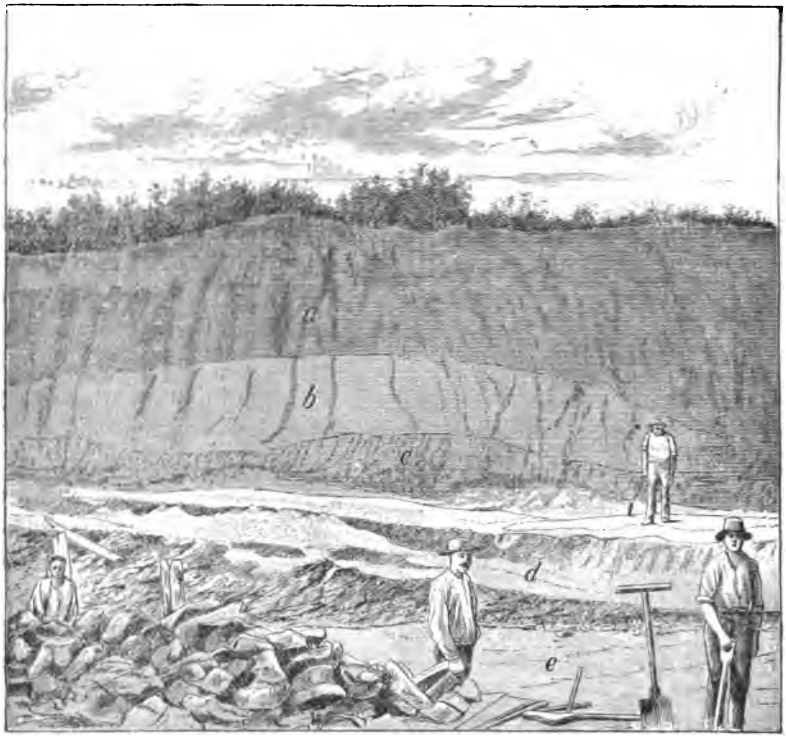
Remarkably fine sections of the relative positions of glacial drift, yellow gravel and the Raritan clays are occasionally exposed in the excavations made to uncover the clays. One in the pits of Mr. Inslee, at Woodbridge, is shown in Fig. 2 on the opposite page.

The upper part, for a depth of 15 feet or more, is a most perfect specimen of unstratified glacial drift. It is a mass of red sandstone earth, pretty evenly mixed throughout with cobble-stones lying in every imaginable position, some resting on their sides, others on their edges, and others still on their ends; as if they had been dumped down in the mass of earth and held in the position in which they fell, with no freedom to adjust themselves with their longer diameters horizontal, as they do when single or in water. But the most remarkable portion of the mass is a body of yellowish quartz sand of uniform quality and weighing 10 tons or more, which is entirely surrounded by the red glacial drift. It is evidently a part of the *yellow* gravel and drift which overlies the clay, and has been taken up by the moving glacier and carried forward with the red sandstone materials of the moraine, and left with the rest lying on the top of this bed of pure *white* clay. The contrast of colors is very strong, and the relation of the several parts to each other is shown with unusual distinctness.

At the pits of Mr. Anness, on the Spa Spring road, west of Woodbridge, where the digging of feldspar is going on, the red sandstone material of the glacial drift overlies the undisturbed yellow gravel and sand, and that in turn overlies the cretaceous beds of white feldspar and clay. The contrast of colors is equally strong with that at Mr. Inslee's, and the section of the yellow gravel and drift is particularly good. The glacial drift is more uneven in its materials, but equally well marked. We present the section as it was taken by photography, and the scale can be judged from the figures in it. It is Fig. 3.

At the Fish House clay pits, on the bank of the Delaware, about four miles above Camden, numerous specimens of the genus *Unio* have been found in a black clay which is used there for making brick.

FIG. 3.

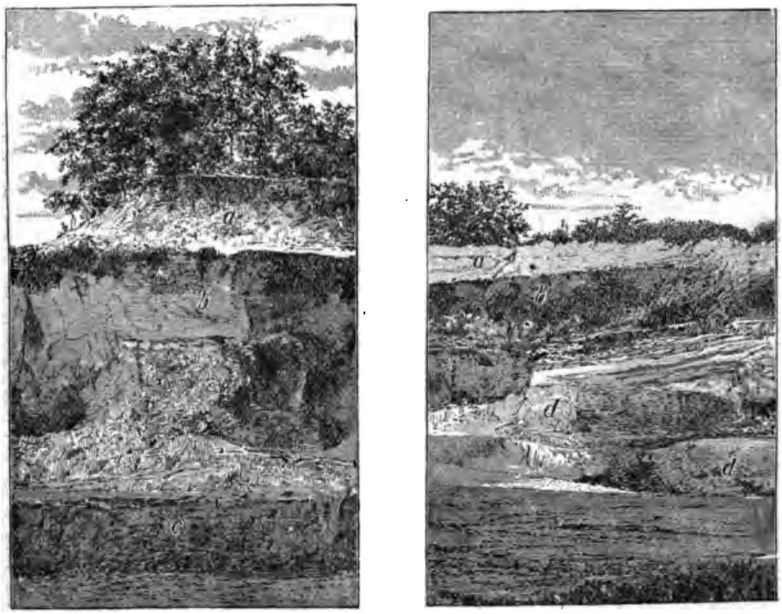


SECTION AT ANNESS CLAY BANK, WOODBRIDGE.

a. Glacial drift.
b. Yellow sand.
c. Yellow gravel.
d. Fire-clay.
e. Feldspar.

Until the past summer no associated beds of clay or sand of known age have been found in contact with it. But the workmen have now found white clay and gravel underlying it, which are identical with those found a little farther east, and with those on the Pensaukin and the Delaware, at various points between Trenton on the north and Bridgeport on the south. And these last mentioned have been recognized by their fossils as of the same age with the Raritan clays on the east side of the State. The black clays containing the *Unio* overlie these white clays, and are probably some later members of the same series. A photograph of the clays and their positions in relation to each other, and to the overlying beds of earth was taken and is here shown in Fig. 4.

FIG. 4.



VIEW IN CLAY PIT AT FISH HOUSE.

a. Fine surface-soil and sand. *b.* Dove-colored clay. *c.* Black clay. *d. d.* White clay, sand and gravel.

The facts here given in regard to the yellow gravel and sand, as well as to the glacial drift, are simply put on record. Many more facts must be collected before we shall be warranted in presenting a systematic arrangement of them or attempting to give the geological age of the various deposits we find between the Miocene of the

Tertiary and the glacial drift of the Quaternary. But most of the information accumulated in the survey has been derived from the observations of others; and if new facts can be published, there is good reason to expect that many more observers will be in the field and ready to gather new facts which may bear on the subjects that are open and unsettled.

V.

TERTIARY AND CRETACEOUS FORMATIONS.

SECTIONS SHOWING THESE FORMATIONS AND THEIR RELATIONS TO THE OCEAN BOTTOM.

The several borings for artesian wells which have been made to the southeast of the marl belt confirm the conclusions which had before been reached as to dip of the Cretaceous and Tertiary strata of Southern New Jersey. And borings on the borders of the ocean, and even out on the sand beaches, which are some miles from the upland, show that the strata outcropping at the high ground in the marl region are continued without change or disturbance of their regularity as far out as these borings have been made. And from the soundings made by the United States Coast Survey, the form of the ocean bottom would indicate that the geological formations of the lands bordering the shore are continued out under the ocean for a hundred miles or more. A section (Plate II.) across the State is here given, with the successive strata met in boring several wells, and as they appear at their outcropping edges on the surface. It is not necessary to give further explanations of this, as it was described in the report of last year, and now it only varies in having a number of other borings put down on it which goes to prove its correctness, and to encourage others to make use of it. The wells spoken of will be described later on under the head of water-supply.

The section* (Plate III.) here inserted to show the remarkable form of the ocean bottom off our shore is an interesting and suggestive one. To look at it, as a whole, it appears as if the real shore of the ocean was 100 miles out from the eastern border of our State, and the intervening distance was only temporarily covered with water like flat grounds on the borders of a river in time of a freshet, and as if they might soon be left dry and the ocean diminished to the area of its deep waters. Such a contraction of its area would diminish the capacity of the ocean but slightly. And looking at it in the opposite direction, it would require but a small addition to the enormous volume of its waters to make them flow inland far enough to cover the whole of Southern New Jersey and all those strata which now seem to run so regularly out under the sea.

For the first 100 miles out the ocean deepens only 3 feet to a mile, or 300 feet in all, while in the 12 miles between 106 and 118 miles out, it deepens from 600 feet down to 6,000 feet; at 156 miles out it is 9,000 feet deep, and at 250 miles out it is over 12,000 feet, or nearly 2½ miles deep.

It is remarkable that while the descent of the shallow part of this ocean bottom is only a twelfth part as much as the dip of the cretaceous strata, the descent of the deep part of the ocean, from 150 to 250 miles out, corresponds almost exactly with the dip of those strata.

* Prof. J. E. Hilgard, Superintendent United States Coast and Geodetic Survey, has furnished the data for this work from their latest surveys.

VI.
TRIASSIC ROCKS.

COLUMNAR TRAP-ROCKS OF ORANGE MOUNTAIN.

The remarkably fine exposure of columnar trap-rock at the quarry of Mr. John O'Rourke, on the southeastern slope of Orange Mountain, has attracted a good deal of public attention during the last few months. The rock is the same with that which forms the crest of each of the three ranges of the Watchung mountains. The fine exhibition which is made at this place is due to the work of Mr. O'Rourke in first clearing away the loose rock and debris from the front and surface of the ledge of trap-rock, and then working in, as he has had occasion to do, in getting out his road-making material, until he has exposed a vertical face of the rock, which is 700 feet long, and 100 feet high in the middle, and 30 feet high at one end, and about 20 feet at the other. The whole of this rock surface which is in sight is made up of prismatic columns as regular in their form as if they had been dressed out by a stone-cutter, and packed together so closely that there are no vacant spaces or openings between them. The columns generally are parallel to each other, and those at the two ends of the quarry are nearly perpendicular, but the large and high mass in the middle is made up of prisms, which are inclined at various angles, generally in a direction towards a central line.

The work which has been done in quarrying here has exposed the structure of this mountain rock, so that it is in admirable condition for study, better, probably, than it can be found anywhere else in the State, and it is more easily accessible than any other in our country, so that it has already been seen by thousands of visitors. A view of the whole quarry is given in the frontispiece. The view is taken when looking towards the northwest, and is near enough to the top of the mountain to show its crest line, with the columns extending all the way up. At the bottom the columns appear to run down to the level surface which is kept for the convenient working of the quarry. In reality they do extend down 6 or 8 feet below the level of the working ground, and stand upon the red sandstone rock which everywhere underlies this trap.

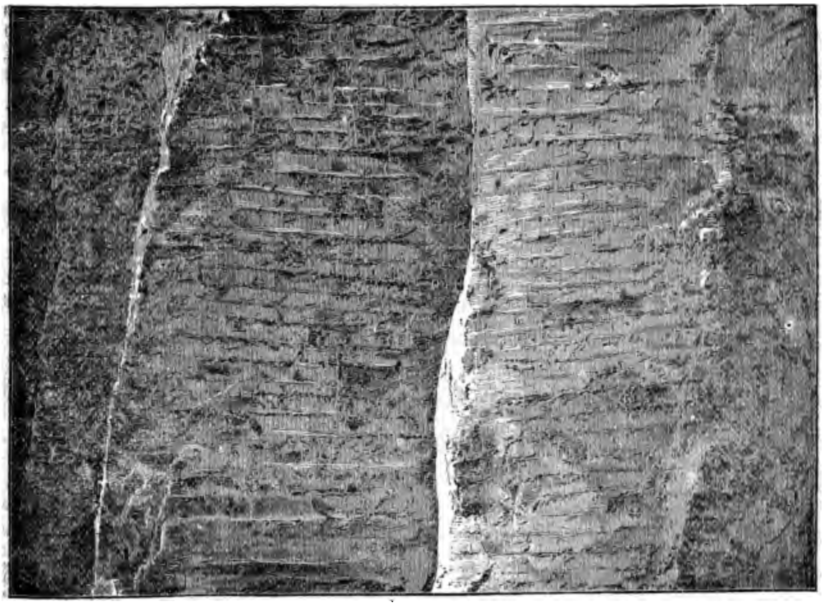
The perpendicular columns at the left hand or southwest end of the quarry are 30 feet or more in height, and are 5 or 6 sided, some of the sides being as much as 2½ feet in width. Those at the right hand or northeast end of the quarry are shorter, 15 to 20 feet in height, and a little inclined. They are larger, however, than the others, some of them having sides 4 feet wide. These very large columns are some of them bent near the top, turning off towards the left, and presenting the appearance of having been crooked after they were formed, and while still soft and flexible. The smaller prisms which make the central mass are much shorter, from 2 to 6 feet long and from 6 inches to 1 foot across a side.

The rock is like all the rest of the trap-rock of these mountains; analysis shows very little difference in their composition; there are, however, plain differences in the stony character of those from different places, or even from different parts of the same quarry. In the present case the surface of the prisms in the middle part is much rougher than in that of those at the two ends, and while the color of the fresh fracture in both is of a bluish-gray tinge, that of those in the middle part is of a little darker shade, and the fractured surface is rougher. In hardness and toughness the large columns at the ends excel, though all are hard enough to make the best of material for roads.

In many basaltic rocks the columns break across with a curved fracture, so as to leave the pieces of the column each with one convex and one concave end. This is remarkably the case in the columns from the Giants' Causeway, in Ireland, and it was shown to some extent in the columns which were figured in the Report for 1882, and which came from a quarry on the left bank of the Passaic, about 2 miles below Little Falls. A little of this cup or basin-shaped structure is to be seen at the lower ends of some of the large columns at the northeast end of the quarry. It is not, however, a marked feature of the rock here.

The surface of most of the large columns are marked as if they were regularly laid up in courses like bricks in a building. These courses are about as thick as common bricks, and have about the same inequality or unevenness of surface that buildings of ordinary brick have. These courses in adjoining columns match each other. They do not, however, extend inwards so as to affect the structure of the rock, for in breaking across any of these courses no trace of them can be seen in the solid and hard rock. A cut (Fig. 5) made from a photograph of these column-surfaces is here inserted, though no apparent cause for this peculiarity is yet seen.

FIG. 5.



SURFACE MARKINGS ON BASALTIC COLUMNS, ORANGE.

Geologically, this rock is recognized as of igneous origin, and it has undoubtedly been intruded, when in a fluid state, between the strata or layers of the red sandstone rock of the country. This last rock lies in great layers, which descend beneath the surface towards the northwest, and the igneous rock has come up between these layers until its edge has reached the surface, and its material has crowded the sandstone layers apart and filled all the interval between them, and has hardened into the great tabular mass which is now exposed along the whole length of these mountains. While the igneous rocks usually show themselves in these intruded masses between the layers of other rocks, still they must have broken their way across the beds of sandstone somewhere, and the outflow of the fluid rock may have been at more than one time. And while looking at the rock in this quarry, it appears plain that the large columns at its two ends belong to the great tabular mass which extends the whole length of this mountain, which is more than forty miles. But the central mass, which at its two ends is so high that it overlies the tops of the two end rows of perpendicular columns, descends in the middle quite down to the working floor of the quarry. And it may be that it extends quite down to the sandstone, and that here is a place where the sandstone has been fractured, and a second outflow of trap-rock has come up here, and, overrunning the former flow, has hardened into the central mass which is here seen. The further opening of the quarry and lowering of its working floor will be looked for with great interest, and with the expectation that a fracture in the sandstone, filled with trap which extends up to the central and higher mass of rock, will be seen.

The prismatic or columnar structure, which is so marked a character in the igneous rocks, is due to some cause not well understood or described. It is observed not only in rocks of this kind, but it is sometimes seen in stratified sandstones which have been long exposed to intense heat, though not melted, which, when cooled off, break up into prisms which may be perpendicular to the lines of stratification in the rock, and are always perpendicular to the surface, where the heating and the cooling have taken place. It has been observed, too, in the same way, in cast-iron which has been long exposed to a high temperature without melting. The prismatic structure in starch has been observed by every one. This forms when the wet starch is drying, and, like the other cases cited, the prisms are always at right angles to the surface of drying.

This remarkable structure, then, does not appear to be characteristic of any particular substance, nor is it due to the changing of material from a liquid to a solid state, nor is intense heat necessary. A shrinkage in the mass, due to either cooling or drying, and showing its effects by this net-work of fine cracks, first on the surfaces cooled or dried, and extending inwards with the diminished temperature or moisture might be sufficient. Such a net-work of fine lines, almost like the divisions of a honeycomb, can be seen on the surface of the bare trap-rock on top of the mountains above the quarry; it is very plain on the surface at Eagle rock, a mile northeast of the quarry, and any number of other localities can be found wherever the rock on top of the mountain is exposed. Something like it, too, can be seen in the drying of the fine mud which is left at the bottom of a pool in which muddy water has stood and settled and then been drawn off or dried up. The mud shrinks and is crossed by cracks in different directions, which leave the surface divided up, much as it appears on the upper surface of this trap-rock.

There are many other places in the mountain ranges of trap-rocks where this columnar structure can be seen. The most noted is the Palisades, in which the face towards the North river is made up of these prismatic columns all the way from Weehawken to the State line. The exposure at Little Falls has been mentioned. Others are to be seen at the Great Falls in Paterson, and also in Garret Rock. Some very large ones are exposed in the mountain between Caldwell and Little Falls.

The Orange quarry has been photographed a number of times. Dr. Lawrence Johnson, of New York, sent to the Survey copies of some very handsome ones taken by himself. And the general view which is inserted as a frontispiece in this report is from a photograph taken by Mr. H. J. Brady, photographer of Orange.

Those who may wish to visit this great natural curiosity will reach it from Orange by going up from the Delaware, Lackawanna and Western depot, about a mile on Mount Pleasant avenue, when the foot of the trap-rock on the mountain side will be reached, and the wagon track on the left can be followed for 400 or 500 feet, when the quarry will be in full view. The Triassic sandstone underlying the trap can be seen by the side of the spring near the smith shop, in front of the quarry. The overlying sandstone has been worn away from the top of the mountain by the long-continued action of the elements, or has been torn off by the moving glacier; but it can be seen in the bottom of the valley a mile northwest, and in the lower slope of the second mountain which forms the other side of that valley. Glacial scratches can be seen on the smoothed upper surface of the trap-rocks wherever they have been protected from the corroding agencies of the weather. And loose boulders of almost every kind of rock which belongs in place within a hundred miles north of Orange, can be found scattered over the surface of the ground or partly imbedded in the earth. A fine moraine of glacial drift can be seen half closing the valley at the dam of the Orange water-works; and the overflow of the pond, which is made across the trap-rock at the northwest foot of the first mountain, has washed off the earth and exposed that portion of the trap-rock which is ordinarily considered to have been cooled without being subjected to much pressure; and it is full of cavities and rounded lumps of prehnite and other minerals common in such igneous rocks.

An excursion to the basaltic columns at Orange, and across the mountain and valley beyond, is full of interesting material; and the view from the top of the mountain is one of the finest on the continent.

VII.
DEVONIAN AND SILURIAN ROCKS.

GREEN-POND MOUNTAIN ROCKS.

A re-examination of the rocks of the Green Pond, Copperas, Kanouse, and Bearfort mountains, and the adjacent outcrops of slate, limestone and gneiss, has brought out some facts which, taken in connection with the observations upon the same range in Bellvale and Skunnemunk mountains, in Orange county, New York, make it necessary to revise the descriptions of these rocks. Their geological horizon is not as low as was stated in the "Geology of New Jersey," in 1868, or as has been represented upon the several issues of State geological maps.

These rocks were referred by the late Prof. Henry D. Rogers, in his reports on the Survey of New Jersey, to the so-called Middle Secondary. He considered them as the equivalents of the calcareous and siliceous conglomerates which occur along the northwest border of the Red Sandstone formation, and which are put in the Triassic age by American geologists. As a matter of historic interest, and in order to a better understanding of all the facts of the case, the following extracts are here reprinted from his reports. In that for 1836, after describing the geographical range, he said: "Its strata range through the mountains above mentioned in bold mural escarpments or precipices, which invariably face the southeast, the uniform dip of the beds being toward the opposite point; their inclination to the northwest is at an angle of about 30°.

"What may be the relative position of this rock to the limestone which shows itself in two or three places upon the southeast of the formation, as west of Mount Hope and near Macapin pond, it would be premature at present to assert, though the probability is rather that the limestone underlies the conglomerate, whether conformably or not we do not pretend to conjecture. This limestone resembles somewhat the Mendham range."*

In Rogers' final report we find the following description:

"OF THE MIDDLE SECONDARY ROCKS OF THE GREEN POND AND LONG POND MOUNTAINS.

"When describing the older secondary rocks of the long, straight and narrow valley which separates the two principal ranges of the primary strata of the Highlands, it was stated that these formations where they appear in the neighborhood of Green Pond and Macapin pond, were overlaid unconformably by a group of much newer date, conceived to have been produced in the middle secondary period. I propose to offer a brief account of the position, structure and probable origin of these insulated strata.

"*Geographical range.*—Tracing these unconformable rocks from New York towards the southwest, they are found to constitute a nearly continuous mountain chain, extending from the western side of Long pond, past Macapin and Green ponds, to a point west of Succasunny. From the State line to the Pequannock, the belt consists of a single ridge, somewhat broken down in some places by denudation—this is known as the Long pond or Raffenberg mountain; but from the Pequannock southwest for several miles the belt is double, the shorter range forming the Copperas mountain, and the longer parallel one the Green Pond mountain, ending north of Succasunny.

"These ridges are for the most part remarkably straight, while their summits are nearly level. Throughout considerable distances they present a succession of bold precipitous escarpments, facing invariably the east-southeast. The strata dip in all cases towards the west-northwest, at an angle which is somewhat variable, but which is usually about 30°.

"The almost perpendicular outline of these ridges on their southeastern side, the repetition of the same rocks in the two adjoining ranges, and their dipping towards the same quarter, are facts which strongly indicate the existence of one or more extensive longitudinal dislocations of the strata. We can hardly conceive how a mere denudation of the surface, unaccompanied by a disrupting movement along certain lines, could have given to the topography of this formation its present peculiar features.

"The Green Pond mountain terminates in three oval-shaped outlying hills in the prolongation of the main ridge, separated from each other and from it by transverse valleys or notches, through one of which the Morris canal has been carried. A fourth low hill, not pre-

* Report on the Geological Survey of the State of New Jersey, by Henry D. Rogers, Philadelphia, 1836, pp. 129 and 130.

cisely in the same line with the others, commences a little south of these and extends longitudinally towards Flanders. It would appear to belong to a different formation from the others, being manifestly an insulated remnant of the sandstone, Formation I., of the Appalachian series.

"*Composition and Structure.*—The formation we are describing embraces two principal members, which preserve their respective characters with very great uniformity. The lowest of these, which reposes sometimes on the primary rocks at the foot of the adjoining hills, sometimes on the lower strata of the older secondary series, originally forming the bed of the valley, is a conglomerate easily recognized. This rock consists of a rather fine-grained, compact, red sandstone, occasionally argillaceous, imbedding rounded, water-worn pebbles of various dimensions, generally composed of white quartz. When these pebbles are large and diversified in their color and composition, as happens in certain beds, and when the paste is less abundant and more argillaceous than usual, the whole mass possesses a considerable resemblance to the less calcareous varieties of the Potomac marble. Bowlders of a rock having these features lie strewed in great numbers in many parts of the red sandstone region east of the Highlands, extending as far as the Hudson, and traceable to this stratum of the Green Pond mountain.

"In the inferior beds, the character of the rock is somewhat different, being in many places almost white, and consisting chiefly of a white sandstone, thickly studded with white quartz pebbles. These layers are conspicuously seen in the outlying low hills, near the southern termination of the Green Pond mountain; they are also visible at many other points, as, for example, ten miles north of Macapin pond. Their contiguity to a tract of white sandstone of the older series, Formation I., suggests this rock as the probable source of the arenaceous materials of these beds. We thus find in this, as in other formations, that the lowermost layers are derived from the more immediately adjacent rocks, being deposited during the first influx of the currents, before time had elapsed for the introduction of the sediments from more distant quarters. Ascending a little, the beds of the lower part of the conglomerate become progressively more tinged with the red matter so prevalent throughout the higher portions of the formation.

"The other division of the formation overlies the former, and is a compact argillaceous red sandstone, much resembling the firmer varieties of the red shale of the district east of the Highlands. It is seen well developed about one mile north of the head of Green pond, where it forms the point of the Green Pond mountain, near the notch or dislocation which traverses it two miles south of the Pequannock. Both in this vicinity and in other parts of the range, this stratum is divided by a system of oblique cleavage joints, which cross the general plane of the dip nearly at right angles, having an inclination of about

45 degrees towards the southeast. These joints impart to much of this rock a slaty structure, calculated readily to mislead the observer respecting the true direction in which these strata have been elevated. The conglomerate is in like manner jointed by planes of cleavage, but at far wider intervals, being divided into large, massive cubodial blocks. These joints observe the same direction and dip as those in the overlying fine-grained red sandstone and shale.

"The total thickness of the formation, including the conglomerate and the red sandstone, probably exceeds 600 feet; but from the appearance of great faults or dislocations in these strata, the determination of their precise depth is attended with much uncertainty.

"*Of the Probable Origin of the Formation.*—From the wholly insulated position of these unconformable strata, encompassed on all sides by rocks of older date, and from the non-appearance hitherto of any organic remains of a distinctive kind, by which to infer their age and mode of origin, we are prevented from arriving at any very satisfactory views regarding the particular circumstances under which they were produced. The striking analogy which they bear, however, to the strata of the middle secondary series both in composition and appearance, and their lying in the same unconformable manner upon the previously uplifted rocks of the Appalachian group, induce us to consider them as deposits from the same mass of waters. This suggestion acquires additional weight, when we reflect that the long and narrow valley embracing this belt of conglomerate and sandstone opens immediately into the great basin of the middle and secondary series. From the denuded condition of the southwestern portion of the Green Pond range, and from the apparently natural outlet which German valley would afford for the waters in their passage across this mountainous district, it seems not improbable that these rocks once filled the bed of this valley throughout its whole length as far as Clinton. At the final elevation of the red shale and sandstone rocks, if, as we suppose, *these* strata were also uplifted, the extensive dislocations to which they have obviously been subjected will account for the removal of a portion of the beds, exposed as they must then have been to the full violence of the floods thus set in motion."*

The formation in Orange county, New York, was examined by Prof. William W. Mather and Dr. William Horton. Their descriptions are in the annual reports of the State Geologists and in the final reports on the geology of the State. Dr. Horton, in his report on the Geology of Orange county, under the head of "Graywacke," says: "Bellvale mountain extends quite across the town of Warwick. The southeast side, the top, and about one-third of the descent on the

*Description of the Geology of the State of New Jersey, being a final report, by Henry D. Rogers, State Geologist, Philadelphia, 1840, pp. 171–175.

northwest side, are composed of graywacke and graywacke slate, standing nearly vertical. Its colors are gray, greenish and bluish-gray and brick-red. Many of the layers are completely chequered by veins of milky quartz traversing them in all directions. While it passes, on one hand, into graywacke slate or graywacke shale, on the other it becomes a perfect conglomerate.

"Skunemunk is similar to Bellvale mountain, passing unbroken nearly across Monroe. Its southeast side, top and part of northwest side, are graywacke, in all the same varieties. It is not in a line with Bellvale mountain, neither do their lines of bearing quite coincide. Most of the mountain has the dip, &c., of Bellvale mountain, but *High Point* has the rock dipping to the east, and some part of it even to the *northeast.*

"On some of the small ridges northeast of Bellvale mountain, the graywacke is seen forming their northwestern sides, while the opposite or southeast side is primitive rock. One of these may be seen a mile west of the Friends' meeting-house, in Monroe. In these cases the line of bearing and dip of the graywacke coincide with those of the primitive, and the graywacke has the appearance of passing beneath the primitive rock. * * * *Pine Hill,* east of Skunemunk, is a graywacke ridge, composed almost entirely of the red, slaty, compact and conglomerate forms."

Under the heading "Millstone Grit (*of Eaton*)": "Round Hill, like the Highland ranges, is primitive, and here the grit rock inclines against it and rests upon it. The grit rock is regularly stratified, line of bearing same as in Shawangunk mountain, but it dips to the southeast. It passes through all kinds of composition, from compact to soft and slaty on one hand, to a coarse conglomerate on the other; and all shades of color, from white to brick-red. From the point mentioned it extends northeast nearly four miles, until intercepted in its line of bearing by a part of Woodcock mountain, which is primitive.

"A similar rock is again found in the southeastern face of Skunemunk mountain, and at its base. But here it is interstratified with the graywacke and graywacke slate, and while all the colors already mentioned exist here also, there are some layers which are different. The pebbles of which these layers are composed, are much larger, and about half of them are very white and the remainder very red. All the pebbles are smooth, as if water-worn.

"These layers extend as far south as Skunemunk mountain, and about two miles farther north than the mountain itself does.

"Pine Hill, a ridge next, southeast of Skunemunk, is composed of this rock; it is near three miles long, narrow and somewhat elevated. In this hill the rock is almost entirely red, and can be quarried in handsome blocks for building. * * * No fossils have been seen in this rock anywhere."*

Subsequently, in the "Geology of New York," Part I., Prof. Mather described these rocks as follows, and under the heading: "*Rocks similar in character to the Shawangunk grit and the interstratified and overlying red rocks.*

"These were observed in Orange county, and they extend from the New Jersey line on the west side of Long Pond, north-northeast to near Canterbury, in Cornwall. They have not been traced continously between the points indicated, but at intervals. This is the same formation as that described by Prof. H. D. Rogers, under the name of the Middle Secondary rocks of the Green Pond and Long Pond mountains. * * * The observations on the geological survey of the first district of New York do not *quite demonstrate* the age of this rock; but if the red slates and grits on the east side of the Hudson, which are the same as those of Pine Hill, in Cornwall, Orange county, are the same as those of Bellvale mountain, near Long pond and the Green Pond mountain, which they strongly resemble, and of which they appear to be an extension, they are older than the Middle Secondary sandstone (New Red sandstone), of New Jersey, to which Prof. Rogers inclines to refer them, and are, probably, the geological equivalents and, in fact, identical with the red rocks overlying and interstratified with the upper part of the Shawangunk grit. At Townsend's iron mine, in Cornwall, the decomposed Delthyris shales, with their characteristic fossils (one of the members of the Helderberg division), are seen, and the red plates of the formation under consideration adjacent, and a coarse, pebbly rock, sometimes white, sometimes red, like the Shawangunk grit, also near at hand in a nearly vertical position. This locality is a mile or two northeast of the northeast point of Skunnemunk mountain, in Cornwall, Orange county.

"The whole extent of this range of red and grit rocks, from the New Jersey line on Bellvale mountain to Townsend's mine, in Corn-

* Third Annual Report of W. W. Mather, Geologist of the 1st Geol. Dist. of the State of New York, 1839. Appendix by Dr. William Horton, pp. 146–7 and 153.

wall, is in a highly inclined position—often vertical, and the same is true of the similar rocks, which are supposed to be an extension of this range from Fishkill, through Dutchess, Columbia, Rensselaer and Washington counties into the State of Vermont.

"The association of the Helderberg limestone with these red slates, grits, and red and white conglomerates may be considered as very strong evidence—almost decisive—that these red rocks are the equivalents of the west side of Shawangunk mountain, and of the central portions of New York, (the Medina sandstones, Oneida conglomerates, Onondaga salt group, and gray sandstone,) instead of the red sandstones of the middle secondary of Rockland county, and of New Jersey."*

The Green-Pond Mountain Rocks were described under that sub-head, and as belonging to the Potsdam sandstone, in the "Geology of New Jersey," 1868.† And on the State geological maps published since that date, they have been colored as Potsdam sandstones and Green-Pond mountain conglomerates. That they are of a later geological age than the Potsdam, will be shown by a study of their relations to associated outcrops and by their fossil organic remains. Their geographical range and a description of their rocks precede the discussion of age.

GEOGRAPHICAL EXTENT.

The most southern outcrop of this series of rocks is in a low ridge which rises near Flanders and trends northeast towards Succasunna Plains. The road from Flanders to Succasunna passes lengthwise over the hill, and the High Bridge Branch railroad runs on its western foot. The slopes to the west and north are gentle, on the east it is not so gradual a descent. The surface shows loose, quartzose rocks in places much mixed with drift. The strata have been opened in the sand-pits on the southern end of the ridge and about one mile east of Flanders, and southeast of Cary's Station. The *sand* dug in these localities comes from the disintegration of the sandstone and siliceous conglomerate. The lines of bedding are seen in the crumbling rock, and also in some of the hard rock which has resisted disintegration in the deeper portions of the pits. The material is rather

* Geology of New York, Part I., by William W. Mather, Albany, 1843, pp. 362-363.
† See pp. 79-89, Geology of New Jersey, Newark, 1868.

coarse-grained and, in places, pebbly. The sand ranges in color from grayish-white to a pink shade. The pebbles are of white, milky quartz. At Cary's pits the dip is 55° S., 35′ E.; at the old pits formerly worked for the Boonton Iron Company it is about 40°, and toward the southeast. The angular grains of sand and the scattering pebbles of white quartz, with a very small percentage of feldspar, show that the rock was like that of the Green-Pond mountain ranges to the northeast. The drift which surrounds this ridge covers the adjacent rocks, and the relations of this outcrop to the other formations about it are unknown.

The next outcrop is northwest of the village of Succasunna Plains. The High Bridge Branch railroad and the Morris canal run close to its north end, and the Succasunna and Drakeville road at the south. Its length is five-eighths of a mile, and its height 818 feet, or 100 feet above the plains on the southeast. There is much loose sandstone on the surface. Ledges of the red rock crop out on the east side and on the south end. The beds dip to the southeast. Here, also, there are no outcrops of other rocks near the sandstone to indicate its relative position.

Less than one mile to the northeast, and in line with the Green-Pond mountain and the Succasunna hill, is the ridge north of McCainsville. The Morris canal skirts its southeast base for nearly a mile. Its length is one and a quarter miles; its height above the level plains is 150 feet, or 865 feet above tide level. The southeast side is very steep and rocky; the drift forms the northwest slope and covers the rock. At the southwest end the stone was formerly quarried for flagging and building. The strata here dip very steeply to the southeast.* But from the bent layers of stone found at this quarry there is evidence of a fold here, as it were—a synclinal folding. The rock is hard, massive, light colored, and nearly all of quartz. On the northeast portion of the ridge the rock is a red sandstone, which splits up into a flagging stone. On the crest there is much loose, red sandstone, and a quartzose conglomerate, derived, evidently, from the underlying rock in place. The drift of the terminal moraine lies upon and around the north foot of this ridge, and the modified drift of the northern end of the Succassunna plains envelops its south end.

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* This locality has furnished the remarkable bent slab of sandstone now in the museum of Rutgers College, at New Brunswick. The specimen shows a bending of about 6 inches in a breadth of 30 inches.

The next outcrop of the sandstone is at the White Rock cut, on the Morris and Essex railroad, near Baker's mills, and one and a half miles east of the Drakesville station. The description of this locality is taken from the "Geology of New Jersey."* The hill here cut by the railroad is about 300 yards long from north to south, and about 200 yards wide. Its height is 791 feet. The cut exposes the rock for 200 yards, and to a depth of about 15 feet. The rock grades from a nearly pure white into a reddish color. In texture it is compact, but not very firm, most of it crumbling easily, although not so readily as that at Flanders. It consists mainly of quartz grains with a little feldspar disseminated throughout the mass. The dip is 45° S., 60° E. Like the hills we have just described, the drift surrounds it, so that the relation of this rock to the gneiss, supposed to lie underneath it, is unknown.

Leaving this line of outcrops, belonging to the Green-Pond mountain range, there is another locality of this red sandstone one-quarter of a mile south of the Drakesville (Morris and Essex railroad) station, and three-fourths of a mile northwest of the McCainsville ridge. The sandstone crop out on the southeastern face of the hill, the mass of which is of gneissic rocks. The most northern limit of the sandstone is 100 yards south of the railroad. The road from Drakesville to the station runs west of it. The ledges on the crest and on the southeast side of the ridge show a dip of their strata toward the northwest, in the opposite direction of that of the McCainsville sandstone. The existence of an anticlinal axis between these two ridges has been suggested as the explanation of these diverse dips.

The position of the several hills described above is indicated on the topographical map, sheet No. 3 of the Atlas of New Jersey. Proceeding northeast the outcrops of these Green-Pond mountain rocks make several long, even-topped mountain ridges, which are prominent features of the surface, and which bear the local names of Green Pond, Copperas, Kanouse, Bearfort and Bowling Green mountains. The extension of the Bearfort mountain is known in New York State as Bellvale mountain. Further to the northeast and in Orange county the rough, rocky and bold Skunnemunk mountain is made up of this series of rocks. The most northern outcrop is in a much lower ridge, which is known as Pine hill, and near Cornwall station, on the New York, Ontario and Western railroad.

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*"Geology of New Jersey, 1868," p. 80.

The Green-Pond mountain is the most remarkable of these mountain ridges, on account of its even-topped, straight course, its simple structure and its bold, east-facing escarpment of conglomerate ledges. It has given name to the formation, although the outcrops are not so many nor so broad as they are in the Bearfort mountain. For convenience of description, the boundaries of the formation in the several ranges are given separately. As the valleys are occupied by rocks of a different age, the boundary lines coincide approximately with the basal contour lines of the ridges or mountains. The description, beginning with the *Green-Pond Mountain,* proceeds northeast and north to the New York State line. And we reprint the account as given in the "Geology of New Jersey," since it is in accord with our latest information: On the west this mountain is bounded by the Berkshire and Longwood valleys, and the valley which opens north to the Pequannock river. The southern end of the range is near the Rockaway river, about half a mile north of the Morris and Essex Railroad. The mountain rises slowly and gradually until its general height is attained, east of Upper Longwood; thence it continues with a remarkably level crest nearly to the Pequannock.* Near the latter stream there is a slight offset to the west, and a depression or gap 300 feet deep crosses the range obliquely, on a northeast and southwest line. The eastern face of this mountain is steep, and throughout most of its length characterized by precipitous bluffs that are from 100 to 200 feet high. The slope to the west is more gradual, although opposite Longwood valley it is quite steep. The western boundary of the formation passes east of the village of Berkshire valley; thence northward for one mile, the road is the boundary line. Leaving this road it keeps at the foot of the steep slope about 300 yards east of the Rockaway at Upper Longwood. Keeping east of the stream, the boundary line runs thence to Woodstock Forge. At the latter place it is only a few rods from the stream. From this point to the Pequannock drift lies against the foot of the mountain. The line of division

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* The following heights are taken from Sheet No. 4 of the Atlas of Topographical Maps: (1) 920 feet, south of the Sparta road; (2) 800 feet, Summit on road; (3) 1,120 feet, west of Middle Forge; (4) 1,300 feet, east of Lower Longwood; (5) 1,282 feet, east of Upper Longwood; (6, 7, 8) 1,247, 1,220 and 1,233 feet, west of Green pond; (9, 10, 11, 12) 1260, 1,231, 1,218 and 1,254 feet, north of Green pond, and towards north end of the mountain. The average height above the Longwood valley is about 500 feet; above Green pond on the east it is 200 feet.

then pursues a direct course, east of the creek, to Petersburg, and then east of the Newfoundland road to the Pequannock river. This road is generally a quarter of a mile east of the mountain's foot, and nowhere exceeds half a mile. The range terminates near Newfoundland, the river running around its northern end.

The eastern boundary line of this range crosses the Sparta turnpike near the corner of the Middle Forge road, which latter runs for some distance at the margin of the meadows, and along the foot of the mountain. It runs close to Middle Forge, along the western shore of the pond and so on until it meets the gneiss that lies between the Copperas and Green-Pond mountains. This gneiss outcrop is very narrow, consisting of several ridges that extend from the south end of Copperas mountain nearly to Green pond. The boundary between this and the conglomerate west of it, passes over the fallen debris, west of the Green-Pond brook, at length crosses it and then follows the road nearly to the site of Pruden's saw mill. Here the brook flows between low hills of gneiss, and the west boundary is a few rods west of it, until the gneiss disappears and the pond is reached. No rocks in place appear at either end of the pond between the two ridges that inclose the elevated lake valley. The gneiss may continue underneath the lake and drift as a separating ridge or rock wall between mountains. A fossiliferous limestone crops out near J. C. Cobb's, about one and a half miles south of Newfoundland, on the road to Green pond. West of it are the ledges of the conglomerate, while on the east and northeast of it, the valley is occupied by drift supposed to rest on slate. The road from Mr. Cobb's to Newfoundland runs a little west of our boundary, crossing in its course some beds of red slaty rock. North of the Pequannock river there is a short ridge, which the West Milford road traverses longitudinally, that may be considered the last rise of the Green-Pond Mountain ridge. It is about a mile long, its northern limit being at the road corner near P. Eckhardt's. The flat meadows of the valley border it on the east and west. It is a low and smooth ridge, showing its rocky basis at but one point—on the east side near Chamberlain's hotel. This is the red conglomerate, and is in place.

Copperas Mountain. This is similar in structure and appearance to Green-Pond mountain. It shows the same level crest and bluffs to the southeast. The Kanouse mountain and ridge to West Milford constitute the prolonged range in Passaic county.*

South of Green pond the conglomerate of this range is separated from the narrow tongue of gneiss by a long and deep gully or gorge. This continues nearly to the south end of Copperas mountain. The two rocks form the opposite walls of this ravine, being in places only a few yards and even feet apart; thence, passing around the south point of this mountain, the gneiss forms the lower portion of the abrupt face while above is the coarse conglomerate. On the eastern slope of the range the line of demarcation between them is very sharply defined by the gneiss ledges which constitute the lower and more gradual declivity, while above are the perpendicular cliffs of conglomerate, with the fallen debris below. The gneiss is in places two-thirds of the way up the slope. The two rocks were nowhere seen in contact, although only a few feet intervene between them in many places. This is the character of the range from Denmark Forge to the Pequannock river, north of which the same phenomena are observed on the slope of Kanouse mountain as far as Macopin pond. West of this pond the range lowers to an altitude of about two hundred feet above the West Milford valley. The boundary line between the gneiss and conglomerate runs west of this pond, then up a valley to the Gould limestone quarry, across the road a little west of the Gould farmhouse; thence along the foot of the ridge, near the sand pits, by Cisco's quarries, and so on to the north end of the range at the village of West Milford. At Gould's and Cisco's quarries, and one intermediate point, the blue, magnesian limestone appears in small outcrops within the boundary just described. Of the valley between Copperas and Green-Pond mountains, south of the Pequannock river, we have already written. North of this river the drift of the valley rests against the foot of the mountain, and the boundary line between them crosses the first road met (going north from the Pequannock), near where a small stream crosses it, or a few rods east of it. The next road (from Macopin to West Milford) is intersected near a

* The height of this range at a few points or summits on the crest, as taken from the topographical map, are as follows: (1) 1,117 feet, near southern end; (2) 1,230 feet, northwest of Denmark pond; (3) 1,243 feet, east of lower end of Green Pond; (4) 1,200 feet, east of Green pond; (5) 1,225 feet, east of the pond and near Green Lake hotel; (6, 7) 1,215 and 1,200 feet, towards the north end; (8, 9) 1,195 and 1,178 feet, Kanouse mountain; (10, 11, 12) 1,033, 1,062 and 1,088 feet, points west and north of Macopin pond; (13, 14) 852 and 801 feet, near West Milford village.

turn in it, at the foot of the ridge. The line is about three-eighths of a mile east of Daniel Cisco's. At Terhune's mill the road approaches the mountain, and about three-quarters of a mile beyond this point it runs at the foot of the hill, and then rises on its slope, going to West Milford. Here the ridge disappears under the diluvial mass of the valley, which stretches away to Greenwood Lake on the north. In this low ground no rock was found except a few outcropping beds of gneiss on the east side of this valley.

Bowling-Green Mountain, and the ridge west of Milton. Bowling-Green mountain consists of a core of gneiss with the conglomerate wrapped about the north end of it, forming the slope toward the valley on the north. Drift of this valley borders the foot of the mountain: our line, therefore, represents the boundary of this rocky slope and the drift level. The whole mountain is so rough and wild that a description of the southern limit of the red sandstone and conglomerate is almost impossible. Beginning at the road from Milton to Sparta, near the corner of the road to Woodport, and near D. S. Headley's, the line runs up the valley on a southwest course to a swamp where a tributary of the Weldon brook heads. Then curving around, the line runs northerly over a mile, when it turns to the south-southeast and follows a small stream, S. 10° E., to a private road, which constitutes its further boundary to the Milton and Longwood road. The latter road is the northern boundary nearly to Milton. Leaving this road, the line runs south of the village, and sweeping around a little valley towards the southwest, crosses the Sparta road a few rods east of the graveyard. North of this road, almost to Russia, the sandstone and conglomerate may be seen in a narrow ridge bordered by the drift of the valley on the east, and by a wet meadow on the west, separating it from the Hamburg mountain. This is a rocky ridge, sloping gently towards the west, but quite abrupt on its eastern side. It is about 2 miles long, and on an average 250 yards in breadth. Whether it belongs to the Bowling-Green Mountain tract, or is a separate outcrop of the conglomerate, is not quite certain, although the configuration of the surface is such as to indicate that they are connected.

Bearfort Mountain. This mountain is partly in New Jersey and partly in New York. In consists, throughout a portion of its range, of two main ridges or crests, between which lie Hank's pond, Cedar pond and several swamps. The western ridge is the highest.* Both slopes are quite steep; that towards the valley of West Milford is much longer than the western. It is one of the most jagged, rough and rocky ridges of the State. The sharp edges of the outcropping rocks appear almost everywhere, except in a few places, where the drift has covered them. Nearly the whole of it is a wilderness, crossed by only two roads. From the State line to Clinton Falls the broad range is unbroken. At the latter place the stream crosses it, tumbling, in several rapids and falls, 90 feet over the ledges, on its way to the Pequannock. Southwest of Clinton the conglomerate appears at a few points as far as the turnpike, south of which the continued but lowering ridge marks its further extent to its southern limit, which is near the river and a little northeast of Oak Hill. The boundaries are here presented in detail. Beginning at the State line, the western boundary line follows up a valley to the Greenwood road. It continues up the valley, along the road from Greenwood to Clinton, and then down another stream to a point about 2 miles north of the latter place. Here it leaves the brook and keeps along the foot of the gneiss ledges, west of the road, for 1 mile; thence, following the gneiss hills, it crosses the outlet of Black pond, passes by William Winter's house, crosses a road that runs north and south, and, striking a small brook, follows it across the turnpike to the south end of the range near Oak Hill. The drift is here so heavy that the location of this line was determined by the conformation of the surface rather than by its materials. Bending around this end of the range, the boundary on the east side has a northeast course. It intersects the road from Clinton to Newfoundland about half a mile south of the former place, and the brook from the falls just below the lower fall. Thence to the New York line it may be said to follow the foot of the mountain and skirt the West Milford valley. It is about a quarter of a mile west of D. Cisco's hotel. The road crossing the mountain

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* Some of the heights of the eastern ridge are: 1,300 and 1,365 feet, between Hank's pond and Cedar pond; 1,351 and 1,236 feet, west of West Milford; and 1,300 and 1,329, west of Greenwood lake. On the western side and north of the Uttertown and West Milford road there is a considerable area above 1,400 feet, and the Terrace pond is at a level of 1,393 feet; while the adjacent crest ledges are 1,490 feet high. The Greenwood lake and Warwick road attains a height of 1,106 feet. North of the road the crest ridge on the west runs at the elevations of 1,352, 1,454, 1,477 and 1,433 feet to 1,377 feet at the State line. The mean height above the West Milford valley ranges from 600 feet to 700 feet above Greenwood lake. The valley on the west, between this range and the gneissic rock ridges is 200 to 300 feet deep.

is intersected about 300 yards from the corner of the valley road. West of the village of West Milford the brook marks the eastern limit of this formation. The Greenwood road is crossed about three-quarters of a mile west of Cooley's. North of this road the boundary line gradually approaches and strikes the lake near the New York line. For this distance the grit rock of the mountain is bounded by a black slate belenging to the Hudson river series.

ROCKS.

The rocks of the Green-Pond Mountain formation are shales, slates, sandstones and conglomerates. Owing to the great variation in the material and fineness of texture, these grade from one into another so that the limits of passage from a shale to a sandstone or from sandstone to conglomerate cannot be always defined. But generally the lines of division are plainly marked, and the boundaries of the several species are capable of delineation.

The shales are usually of a bright red color, and of a rather coarse, gritty and arenaceous nature. They are in places dark brown to almost black shade. And fine, argillaceous shales also are seen, as south of Newfoundland a half mile, on the Green Lake road. But they do not fall to pieces so readily and form a soil in disintegrating, as the Triassic shales of the central part of the State.

The slaty rocks also are of varying shades of color, from deep red to black. The prevailing shades are brownish red to red. These slaty rocks are closely allied to the shales, differing not so much in material as in the cleavage which marks them as properly slates. Very good localities of exposure are on the west foot of the Green Pond Mountain, from Berkshire valley to Petersburg, and also on the north point of Bowling Green mountain, near Milton. The surface strata are too fragile for roofing slate.

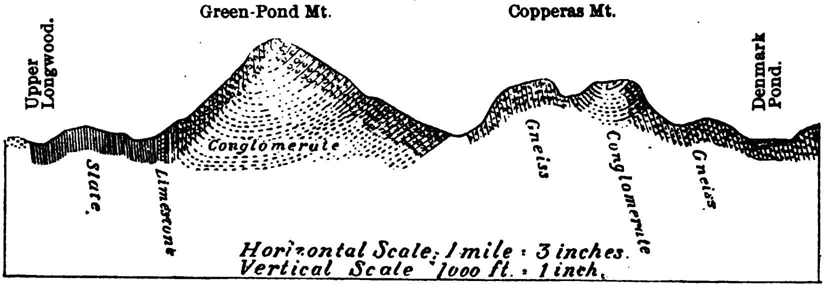
The sandstone of this formation varies greatly in color, texture and nature of its material. The gray and red varieties predominate, and, so far as now known, there is no relation between the shade of color and the position in the series. The red sandstone is, however, more common with the conglomerates—in many places interbedded with it. A schistose or laminated structure is almost everywhere to be seen, and the rock splits quite readily into thin flagging stones. At some points it appears to have been caused by cleavage, like that of the slaty rocks. Very little of the sandstone can be said to be massive, or split equally well in all directions. The *grain* runs with the bedding in most cases, and what may be termed a *flaggy* structure is a common feature. It is especially well marked in the gray sandstone, and not so plainly in the red beds associated with the conglomerate. Much of the sandstone verges on a shale and is fine grained, but the prevailing varieties are coarse grained to conglomeratic, carrying small, scattering quartz and sandstone pebbles. Sometimes the same bed will have two or three irregular layers or lines of pebbles, from one to several inches in thickness. Again, the sandstone has been observed to become pebbly, following it on the line of strike. The cementing material in the sandstone is nearly always silicious, and the mass of the stone almost exclusively silica.

The conglomerate of the Green-Pond mountain series is characteristic in its appearance. The typical species consists of a silicious, red paste of angular quartz grains and small fragments, holding pebbles of white quartz, which are often subangular, and range from one-half inch to sometimes four inches in length. A comparatively few brownish-red quartzose pebbles are often seen with the white quartz. Pebbles of reddish and also of gray sandstones and shaly rocks also occur. They are usually much smaller and much more worn than the white quartz. Gneissic rocks and limestones do not appear among the materials composing these conglomerates. This rock is hard and massive, and it is in very thick beds. In fact, bedding planes are seen only at intervals of several yards, and the stratification is made out with difficulty. The conglomerate is so hard that it resists weathering and forms the precipitous sides of Green Pond, Copperas and Bearfort mountains. From its prominence the name has been transferred to the whole series—which has been styled the "Green-Pond Mountain Conglomerate."

GEOLOGICAL STRUCTURE.

The dip of the strata and the adjacent rock outcrops in the isolated hills from Flanders to the Morris and Essex railroad, have been referred to in the descriptions of those localities. The structure of the longer outcrops in the mountains, described above, is not so simple, but complicated by foldings and by faulting of the strata. These ridges or mountains are not what are termed by geologists monoclinal in structure, that is, having their beds all inclined in the same general direction, but they appear to be made by a synclinal folding of their strata. A cross vertical section would correspond somewhat to the letter U. And the strata on the opposite sides or mountain slopes, dip towards a central plane, which is called the axis of the fold. Where the axial plane is inclined, or dips at a considerable angle from the vertical, the beds on the opposite sides may dip in the same direction, but then the amount of the dip differs greatly on the two sides. As an illustration of a synclinal fold, the following section of Copperas mountain, near Denmark, is here shown. The underlying gneissic strata at the locality all dip steeply toward the east-southeast. The sandstone and conglomerate near the top of the mountain and on the west side, dip at a small angle toward the south-east. Not more than 200 feet to east the conglomerate has a dip of 55° to 60° toward the northwest. In the Green Pond mountain, on the same section line, the east-side beds dip at a moderate angle to the northwest; whereas, over the mountain and near Upper Longwood, the dip is 80° toward the northwest also. The Copperas mountain is a normal synclinal fold; the Green-Pond mountain structure is that of a highly inclined fold.

FIG. 6.



SECTION FROM UPPER LONGWOOD TO DENMARK.

A better section of a fold than this one of Copperas mountain has been constructed from observations recently made upon the outcropping strata of Skunnemunk mountain, in Orange county, New York. The line of this section runs a south course from Woodcock hill, near Washingtonville, to the top of the mountain; thence, on an east-north-east course to Mountainville, in the valley on the east of the mountain.

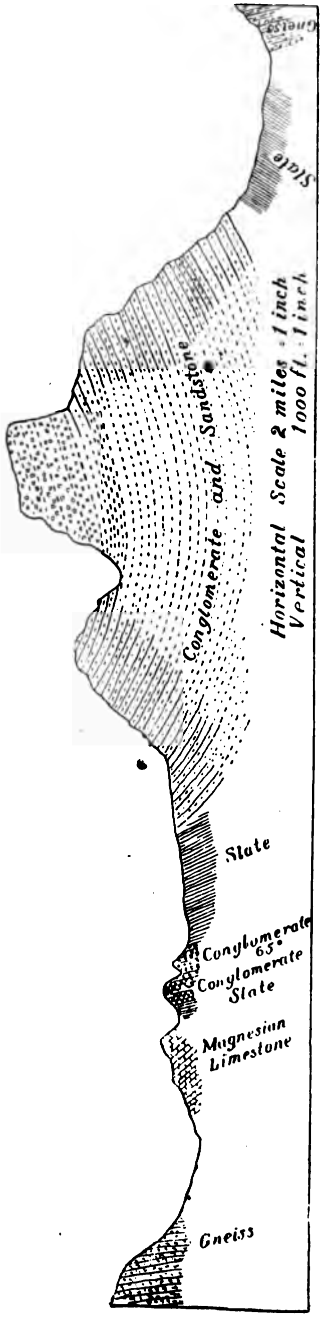


FIG. 7.

SECTION FROM WOODCOCK HILL, SOUTHEAST AND EAST ACROSS SKUNNEMUNK MOUNTAIN, ORANGE COUNTY, N. Y.

The gneissic, limestone, slate and Oneida conglomerate rocks are shown on the left end of the section, all dipping to the southeast; then there is an interval of concealed rock stretching up to the foot of the steep mountain slope; next comes the easterly dipping gray, flaggy sandstone; and, at the top, there is the massive conglomerate, which is, as it were, the keystone of the inverted arch; descending on the east slope there is the gray sandstone with its westerly dip, followed by the black, slaty rock at the foot of the mountain.

The structure of Skunnemunk mountain indicates the higher position of the conglomerate in the series, and, apparently, at the top. At Denmark the conglomerate and associated red sandstone beds repose directly upon the gneissic strata. The outcrops along the whole length of Copperas and Kanouse mountains show the same juxtaposition of these two rocks and their unconformability. The conglomerate appears there to be at the base of the series; or the gray, flaggy sandstone is wanting.

The position of the strata in the several localities of their outcrop may be best indicated by the dips, and they are arranged below in a table, according to a geographical order.

TABLE OF DIPS.

Green-Pond Mountain.

DIRECTION.	AMOUNT.	LOCALITY.
S. 50°–55° E.	70°–75°	At an old quarry, near the Sparta turnpike.
N. 50° W.	60°	Berkshire Valley and Middle Forge road.
N. 35°–45° W.	75°–85°	(Red shale), east of Upper Longwood.
N. W.	Very steep.	(Conglomerate), southeast of Woodstock.
N. 50° W.	50°	West slope of mountain, east of Petersburg.
N. 45° W.	Steep.	" " " "
S 25° E.	40°	50 yards west of Righter limestone quarry, Middle Forge.
N. 30° W.	40°	West of Denmark.
N. 40°–50° W.	Steep.	(Conglomerate), west of Green Pond.
N. W.	......	Northwest of Green Lake hotel.
N. W.	45°–50°	(Red shale), ½ mile south of Newfoundland.
N. W.	Moderate.	Near Chamberlain's hotel, east of Newfoundland.

Copperas and Kanouse Mountains.

S. E.	Gentle.	West slope, at southern end, near Denmark.
S 65° E.	20°	West slope, just above gneiss, south end, near Denmark.
N. E. *strike.*	Vertical.	Near top of mountain, south end, near Denmark.
N. W.	55°–60°	East slope, near gneiss, south end, near Denmark.
N. 35° W.	50°–55°	Road over mountain, southeast of Green Lake hotel.
N. 25° W.	55°	Eastern slope of mountain, east of Green Pond.
N. W.	40°	" " " "
N. 60° W.	70°	Top of Kanouse mountain.
N. 35° W.	50°	Quarry in sandstone, west slope, Kanouse mountain.

Copperas and Kanouse Mountains—*Continued.*

DIRECTION.	AMOUNT.	LOCATION.
N. 50° W.	40°	(Conglomerate), east face Kanouse mountain, south of Macopin pond.
N. 55° W.	60°	Near L. Payn's, south of Cisco's quarry.
W. N. W.	Very steep.	(Conglomerate), ridge 2 miles south of West Milford.
N. W.	......	East of Terhune's G. M., West Milford.
S. 65° E.	70°	Near the M. E. church, near West Milford.
Strike N. 25° E	Vertical.	" " " " "

Bowling Green Mountain and the Ridge west of Milton.

E. S. E.	40°	1 mile southeast of Milton, on road to Longwood.
S. 60° E.	30°	Eastern slope of Bowling Green mountain.
S. 75° E.	40°	Bowling Green mountain. (Hauesser's notes.)
S. 70° E.	45°–50°	Bowling Green mountain, sandstone. (Hauesser's notes.)
S. 70° E.	......	Bowling Green mountain, conglomerate. (Hauesser's notes)
N. W.	......	West side of Bowling Green mountain.
N. W.	......	On the road to the Ford mine, from Milton.
N. W.	Steep.	North end of the ridge, near Norman's.
N. E. *strike.*	Vertical.	Crest of this ridge, near its north end.
N. W.	......	On the east side of this ridge.

Bearfort Mountain.

	DIRECTION.	AMOUNT.	LOCATION.
	N. 50° W.	30°	(Sandstone), Clinton Falls.
	S. 45° E.	Steep.	West of D. Cisco's hotel.
	W. N. W.	Very steep.	(Conglomerate), West Milford and Uttertown road.
	W. N. W.	Nearly vertical.	(Gray sandstone), foot of mountain, Uttertown road.
	S. 55°–60° E.	40°	Warwick road, west of Greenwood lake.
	E. S. E.	80°	(Conglomerate), Warwick road, west of Greenwood lake.
	Easterly.	Steep.	(Red shaly rock), top of mountain, Warwick road.
	S. 70°–75° E	Steep to vertical.	(Gray sandstone), near Uttertown, west side of mountain.
	Easterly.	80°	(Sandstone), near Uttertown, west side of mountain.
Orange Co., N. Y.	S. 65° E.	Vertical.	Top of Bellvale mountain, Warwick turnpike.
Orange Co., N. Y.	E. S. E.	Steep.	(Gray sandstone), near gneiss, west side of mountain, and east of Bellvale village.
Orange Co., N. Y.	S. 70° E.	75°	(Conglomerate), crest of mountain, north of road.
Orange Co., N. Y.	E. S. E.	70°	(Gray sandstone), Trout brook, north of Bellvale mountain.

From these tables of observed dips it appears that in the Green Pond mountain the beds near the southern end dip steeply toward the southeast. Northward, the direction is northwest or west-northwest. On the eastern slope the inclination is at a less angle that it is on the west side. Near the limestone outcrops, at Woodstock and Upper Longwood, the strata stand up almost vertical. All the rocks here are overturned, so that the older limestones lie against and partly upon the red slaty beds of the Green-Pond mountain series. Near Newfoundland, the red shale dips to the northwest, and apparently under the conglomerate of the cliffs to the west of it. As these red shaly and slaty rocks (for the shale is traversed by cleavage planes), crop out on each side of the mountain and near the foot, whereas the conglomerate is higher up on the east face and on the top, the slaty beds appear to be geologically lower than the conglomerate; and the ridge is, apparently, a close fold of the synclinal type.

The fold at the south end of Copperas mountain, near Denmark, has been referred to on page 45. The northern end of the mountain does not show any section like that of this southern end, and it is doubtful if the synclinal structure continues throughout its whole length. In the Kanouse mountain range (which is a continuation of the Copperas mountain) there is a noticeable difference in the amount of the dip on the opposite sides—thus: on the east the average dip is 40°–50°; on the top and on the west slope, it is 50°–70°, to vertical, the strike being constant, from one side to the other. The interpretation of these phenomena seems to be that there is a fold whose axial plane dips steeply to the northwest—that is, we have an example of what is known as an overturned or collapsed synclinal fold.

In Bowling Green mountain the observations are too few to show what may be the structure, with any degree of certainty. The red, slaty rocks are, however, here also at the northeast foot of the mountain, followed by the sandstone and the conglomerate.

Bearfort mountain is probably a synclinal fold, but the observed dips are not so distributed as to show with certainty that it is such in structure. The red conglomerate appears on the crest and the upper part of the west slope in the form of massive, projecting ledges and bold cliffs as in the Green-Pond mountain. The lower part of the western slope, and of the eastern foot also, are made up of strata of sandstone and shales. Much of the rock might be termed a slaty grit or *graywacke* (the designation given it in the New York State reports.) Sandstone occurs interbedded with the conglomerate of the top and red shale also. A notable outcrop of the latter rock, about 50 feet wide (measured across the strike), and bounded on each side by the red conglomerate, is passed over on the road from Greenwood Lake to Warwick.

Bellvale mountain, the northward extension of Bearfort mountain into New York, has the same structure. The thin-bedded, gray sandstone, close to the gneiss, on the western slope, stands up, nearly vertical, and, apparently, conformable to the gneiss. Both rocks dip steeply toward the southeast. The ledges on the crest, northward from the New Jersey line, for several miles are of conglomerate and red sandstone mainly. Further northeast these rocks disappear and the outcropping strata are of dark, drab-colored slate and gray, thin-bedded sandstone or grit rocks. Along the valley of Trout brook, where it crosses the Bellvale range prolonged, the rock thus exposed is an arenaceous slate, approaching, in places, the coarseness of a grit or sandstone. This range of grit or grayish, thin-bedded sandstone is traceable thence northeast, across the Erie Railway line, between Monroe and Oxford, to the high and rocky Skunnemunk mountain. The synclinal structure of the Skunnemunk elevation has been shown in the profile—on page 46. The well-defined and normal type of a synclinal fold in this mountain, the order of superposition in the strata of shale, sandstone and conglomerate, and the numerous and almost unbroken succession of outcrops from its base to crest line, make it typical of the whole range of Green-Pond mountain rocks. And its relations to the adjacent formations and its fossil organic remains give the clew to the geological age of the series. In New Jersey the folds are more or less overturned and are not as easily detected, excepting after many observations. The mountains consisting of synclinals, the valleys lying between these ranges, as that of West Milford, are the eroded edges of anticlinals, whose strata descend toward and pass under the rocks of the former. The softer slates and shales have been worn down into longitudinal basins or valleys while the harder sandstones and conglomerates are left, making the mural walls and steeply-sloping mountain slopes.

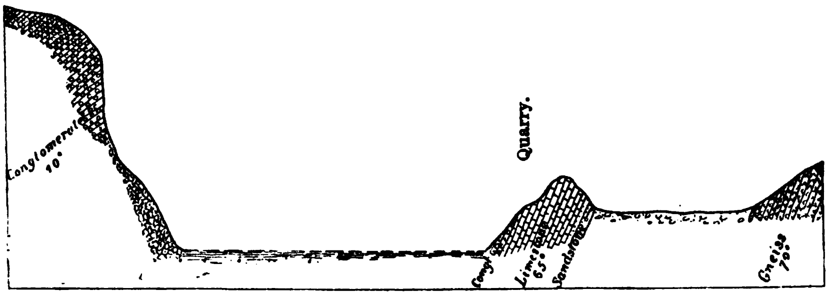
GEOLOGICAL HORIZON AND AGE.

As stated above, on page 30, the Green-Pond mountain rocks were referred by Prof. Henry D. Rogers to the Middle Secondary, and by the present Survey to the Potsdam epoch. In the New York State Reports they were described as belonging to the horizon of the Shawangunk or Oneida conglomerate. That the Green-Pond mountain conglomerate is not Oneida, seems to be indicated by the occurrence of another conglomerate, in isolated outcrops, along the range of Green-Pond mountain rocks, which is identical in composition with that of the Kittatinny and Shawangunk mountains, and which lies unconformably upon the black slate of the Hudson. The conglomerate of the Green-Pond mountain series is a distinct and characteristic rock, and unlike that of these detached outcrops. The latter are seen near Greenwood lake, associated with Hudson river slate and a red sandstone, which may belong to the Medina epoch. Another outcrop is northwest of Monroe, in Orange county. The sketch-map opposite is here inserted to exhibit the relative position and location of the several outcrops of that interesting geological location.*

The succession of gneiss, magnesian limestone, slate and conglomerate, all dipping, in their outcropping strata, towards the east and toward Skunnemunk mountain, indicate the superior position of the latter and its later geological age. The section referred to on page 46, also exhibits, in profile, the dip of the strata west of the Skunnemunk mountain at another locality, viz., near Woodcock hill, and southeast of Washingtonville. On stratigraphical as well as on lithological grounds, the Green-Pond mountain series is shown to be above the Oneïda horizon.

That it is above the Potsdam and the magnesian limestone also, is proven by the order of superposition at several localities. First, at Macopin, the Gould limestone quarry exhibits a section which has the sandstone and then the magnesian limestone, followed by the conglomerate. The vertical section, constructed from observed dips and distances, is here inserted.

Kanouse Mt. FIG. 8.



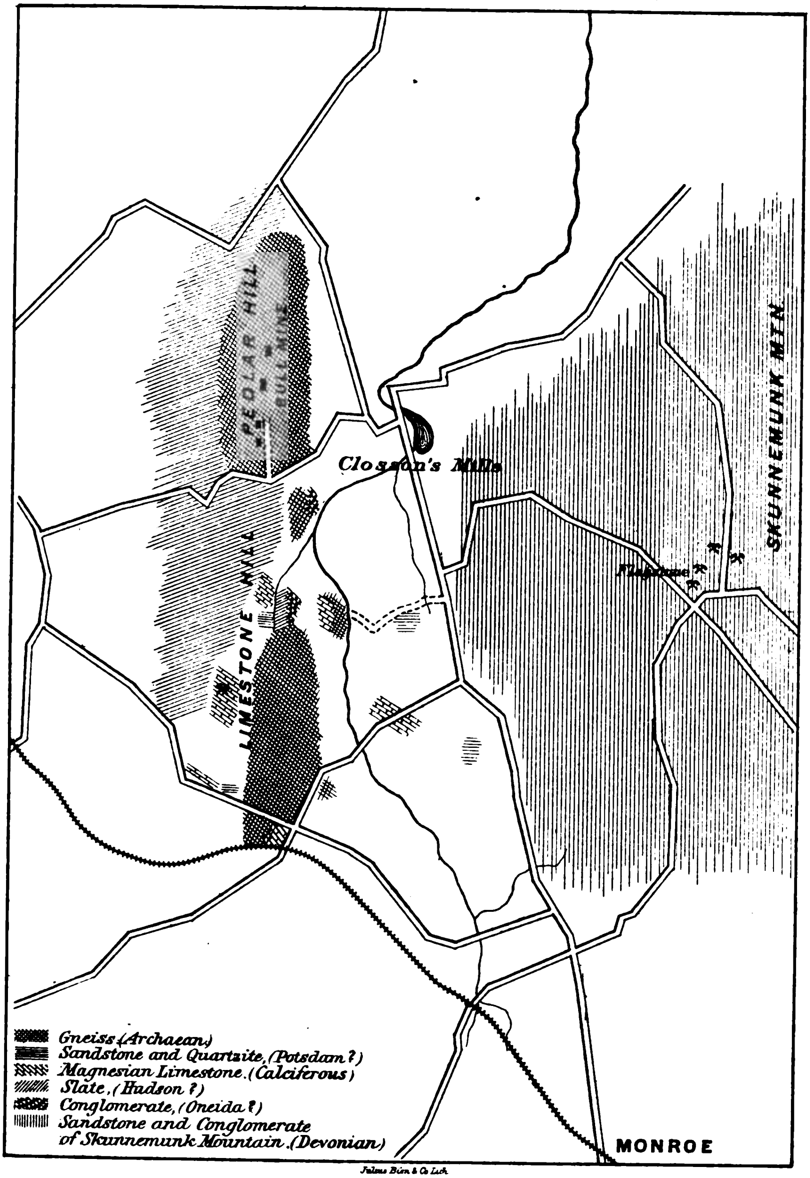
SCALE.—1 inch — 100 feet.

SECTION AT GOULD QUARRY, MACOPIN.

In the section the gneissic rocks are seen on the east side or right-hand, and dipping in their beds toward the northwest. Then there is a concealed interval of 110 feet; the grayish-white sandstone and the silicious and fine pebbly conglomerate represent the Potsdam; then come the pale-blue and drab-colored limestone of the quarry; and, adjoining this stone on the west and conformably lying upon it,

* This New York locality is here given, as it shows much better the relations of these several rocks to one another than any in New Jersey.

A Sketch, showing Geological Formations near Monroe, Orange Co. N. Y.



Julius Bien & Co Lith.

is the single bed of silicious conglomerate, which may be of the Green Pond mountain series; next is a second interval of 300 feet; and then the talus and cliffs of the Kanouse mountain, all dipping at the same angle toward the northwest. The breadth of the limestone here is 60 feet. Inasmuch as the magnesian limestone at the quarry has in it some large masses of quartzose rocks, it is possible that the single bed on the west of the limestone, as here opened, may be only another but larger mass of such included conglomerate, derived from the older Potsdam formation. The dip toward, and apparently under, the conglomerate of the Kanouse mountain, of itself, however, favors the theory of its inferior position.

Another and similar section can be seen at the Cisco quarries, which are 2 miles north of the Gould place. The gneiss on the eastern ridge there has a steep dip toward the northwest. The grayish-white sandstone is well developed south of the limestone, but close to the gneiss. It, also, has a northwest dip. The blue and drab-colored magnesian limestones have been opened at points along the valley bottom for half of a mile from north to south. On the west a narrow meadow separates this rock outcrop from the conglomerate. All are dipping steeply in one direction—to the northwest.

On the western side of the range, in the West Milford valley, the black slate is seen dipping each way from an anticlinal axis, towards the conglomerate and sandstone ridges. If this slate be of the Hudson epoch, then the latter are of more recent formation. The slate in the Longwood valley and at Petersburg occupies a like position, although neither there nor in the West Milford valley are these rocks to be seen in contact or very near one another in their outcrops.

The section at Upper Longwood seems to show the sandstone and red, slaty rock as under the limestone, which is recognized by its fossils as belonging to the Trenton period. But this apparent inferior position may be due to an overturning of the strata, as above stated. At Woodstock the limestone looks as if it were in a fold, and, at the bottom, it has a southeast dip or under the red slate.

The Middle Forge limestone has been so exposed by quarrying that the folding of its beds is to be seen. And, knowing this fact, it is scarcely safe to conclude from so shallow openings as those at Upper Longwood and Woodstock, that as the limestone lies on or leaning, as it were, against the Green-Pond mountain rocks, it belongs to a recent formation. The more regular bedding and the much longer exposures of these rocks at Macopin, are more to be relied upon as showing correct relation.

The Cobb outcrop of fossiliferous limestone, one mile south of Newfoundland, is another so limited a patch of rock, and so far from any other ledges, that it is not safe to draw any conclusions from it indicating its relative position, as compared with the Green-Pond mountain conglomerate on the west, or the Copperas mountain on the other side of it.*

Crossing into New York on this range of rocks, there are like small outcrops of limestone and slate on both sides of Bellvale mountain, but they are also indecisive and of little importance in this question.

Proceeding northeast, the Skunnemunk mountain range appears to afford satisfactory proofs and to give data upon which to base the age of these rocks. The section on page 46 shows a cross vertical profile of the mountain from near Washingtonville to Mountainville, on a south and east line. This section exhibits the gneissic rocks on each side; the blue, Magnesian limestone, the black (Hudson river) slate, and the (Oneida) conglomerate on the west, all having their beds dipping toward the southeast. The slaty sandstones and the thin-bedded grits, or gray sandstones (flagging stones), are shown, with their inward dips, capped by the peculiar and characteristic red conglomerate. Here the conglomerate and the sandstone are seen above the Silurian slates and limestones. And the former have been preserved in this gently-folded synclinal. Elsewhere it must have been broken up in the uplifting and bending of the strata and afterward removed by glacial forces, which have left so many traces of their planing and polishing work on these hard rocks.

The occurrence of plant remains in this series has been referred to above. They are found in the gray-red, shaly sandstone of Skunnemunk mountain. The locality where they can be most readily seen is at the Davison quarry, at the southwest point of the mountain and 3 miles northwest of Monroe.† A few fragmentary specimens

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*The "Geology of New Jersey," 1868, refers to these localities of Upper Longwood, Woodstock and Cobbs' as Trenton, and also as outcrops of formations which pass under and are older than the Green-Pond mountain conglomerate. See pp. 133–134.

†Dr. J. S. Newberry, of Columbia College, N. Y., has identified the following species in a collection from this locality, now in the cabinet of Prof. D. S. Martin, New York city: Lepidodendron *Gaspianum* (Dawson); Psilophyton *princeps* (Dawson); Calamites *transitionis* (Goeppert).

have been found on the east side, also, and near Woodbury falls.* These plant remains are identified as specifically the same with those collected and described by Prof. James Hall, State Geologist of New York, and by Dr. Dawson, of Montreal, from localities in central and southern central New York, which are recognized as Hamilton and Chemung or Middle Devonian. That these rocks resemble, lithologically, some of the flagging-stones of the Hamilton in Ulster, Sullivan and Greene counties, is evident at once on a cursory examination. The absence of any remains of animal life leave the full proof of geological equivalency in doubt. The great thickness of conglomerate at the top and the prevalence of gray and green shales, with the red shales and sandstones, look more like the Catskill rocks or Upper Devonian. It is safe, however, to put them in the Middle Devonian.

THICKNESS.

Accurate measures of the total thickness of the Green-Pond mountain formation in New Jersey cannot be given, on account of the gaps in the observations on section lines crossing them. The minimum measure is obtained at several localities, where the succession of strata is plainly exposed in steep slopes and nearly vertical cliffs. At the southern end of Copperas mountain the thickness of the series from the underlying gneiss to the top of the mountain, and near the axis of the synclinal fold, does not exceed 200 feet. Similar measurements on the east slope of the mountain near the Green Pond iron mines, give a rise of 250 feet. At the north end of the Green Pond mountain, one-half mile southwest of Newfoundland, the elevation at the foot of the cliff is 780 feet; that of the mountain is 1,254 feet, equivalent to a thickness of 474 feet. But the talus of fallen blocks of conglomerate and sandstone conceal the lower strata, although it is highly probable that the whole rise is a succession of gently dipping strata, without repetition or folding. Bearfort mountain range, west of the village of West Milford, rises from 500 to 600 feet above the valley, but on account of the steep inclination of the beds the elevation is not a measure of thickness. At Clinton Falls, and thence to the mountain top near Hanks pond, the more nearly horizontal strata can be seen rising 200 feet above the plain country.

* In a collection of plant remains made in the autumn from these localities, rhizomes of the Psilophyton abound. A species of Calamites also appears.

Taking the angle of dip into the computation, the east face of Copperas mountain shows a rise of 250 feet in a horizontal distance of about 600 feet, and, as the average inclination is at least 45°, the thickness thus obtained amounts to 650 feet. In the east and west slopes of Skunnemunk mountain, New York, the strata are beautifully laid bare in the beds of small streams, and, as the dips are at small angles, the height of the crest above the valleys on each side approximates to the thickness of strata in these sections. The highest crest has a maximum elevation of 1,600 feet* above tlde level; the valley on the west is about 600 feet; that on the east 300 feet, making a difference of 1,300 feet for the height of the mountain. A still better exposure of these rocks is seen on the road west, descending the mountain from the Seven Spring Mountain House. This section, three-quartess of a mile long, shows a nearly unbroken succession of ledges, whose beds have a nearly uniform dip of 20° toward the east-northeast. Allowing for the difference in the length, as measured on the line of the dip, and taking 20° as the mean descent of the strata, the thickness, as computed for these elements, would be, at least, 1,300 feet. If to this figure be added 300 feet for the conglomerate, which is not in the section, there is a total of 1,600 feet. The greater development of the gray, thin and evenly bedded sandstone, going northward, makes the greater thickness in New York. The New Jersey outcrops do not, anywhere, indicate a greater thickness than 1,000 feet, including the shales, slates, sandstones and conglomerates, or the whole series.

* Bar. obs.

VIII.
ARCHAEAN ROCKS.

In the annual report of the State Geologist for 1883, the results of the surveys and studies of the crystalline rocks of the Highlands, were brought together in Section V. of that report under the title of "Archaean Rocks and Iron Ores."* The geographical extent and surface features were briefly described; the kinds of rock characteristic of the district, including the magnetic iron ore, were mentioned; and, under the head of geological structure, the terms "dip," "strike," "pitch," "folds," "faults" and "pinches," were defined and illustrated by references to localities and sections drawn from nature. At the end of the section a few paragraphs were devoted to unstratified rocks and dikes. No thorough study of the rocks collected had then been made, and there was no attempt at any lithological description of them.

Work in the Highlands was resumed last October, and the scheme then laid down was to ascertain, *first*, if any division of the so-called Archaean rocks, other than that adopted in 1873,† could be made, based upon characteristic differences in the rocks themselves, or in their features of strike and dip; and, *second*, the collection of typical rock varieties which could be used in subsequent lithological examinations. One month only of the season was devoted to this work, and the field exploration was confined to the outcrops of the crystalline rocks in parts of Passaic and Sussex counties. Two sections, or lines, crossing the Highlands from southeast to northwest, were traversed in prosecuting the field examinations. One section was from the Ramapo river, near Oakland, in Passaic county, over the Ramapo mountain to Midvale, thence up the valley of West Brook to Upper Macopin, over the Green-Pond mountain rocks of the Kanouse

* Ann. Rep. State Geologist, 1883, pp. 27–77.

† Ann. Rep. 1873, pp. 12–15.

and Bearfort ranges and West Milford valley to the crystalline rock outcrops near Uttertown; thence across the country south of Wawayanda lake to Vernon, Sussex county. Crossing Pochuck mountain the line of exploration was on the road south of Glenwood, going over the ridge in a northwest course to Milton. The southern section line was from Pompton across the south end of Ramapo mountain and near Rotten pond to Wanaque; thence west, on a line nearly parallel to the general course of the Pequannock valley (and from one to two miles north of it) to Macopin lake. Resuming the examination west of the belt of newer Green-Pond mountain rocks at Stockholm, the route was by Two Bridges to Franklin Furnace, in Sussex county. Pochuck mountain was again crossed, but on a line near the Deckertown and Vernon road. So far as could be done, all the outcrops and strata on the lines traversed were examined. And many to the north and south were also visited, so that the observations were not confined to single routes, but were over more or less of a belt 1 to 2 miles wide. Owing to the drift and alluvial coverings, there were many gaps of concealed strata. The work of collecting specimens was limited to such as appeared to be types of outcrops. The observations upon the position of the strata did not, in many places, extend to measurements of the angles of dip and strike, but notes were made of the direction. The following list of localities where the dip was observed is here inserted, showing the general position of the strata on these two sections across the Highlands. A few unclassified observations are also added. And they may all be regarded as supplementary to the long list printed in the annual report of last year.*

TABLE OF DIPS.

DIRECTION.	AMOUNT.	LOCALITY.
S. E.	70°	Near Pompton Junction, and west of railroad.
S. E.	Steep to vertical.	" " east of railroad.
E. S. E.	55°–60°	Wanaque quarry, west of railroad station.
N. 80° W.	70°–75°	Brown, or Kanouse mine, Wanaque.
N. 70° W.	80°	Foot of mountain, east of Kanouse mine.

* Ann. Rep. State Geologist, 1883, pp. 39–50.

TABLE OF DIPS—*Continued.*

DIRECTION.	AMOUNT.	LOCATION.
S. 70° E.	75°	East foot of Ramapo mountain, and north of Oakland.
S. 65° E.	80°–85°	Ramapo mountain, northeast of Rotten pond.
S. 75° E.	80°	Ramapo mountain, west of Rotten pond.
S. 60° E.	60°	Ramapo mountain, west of pond and on west ridge.
E. S. E.	Steep.	West slope of mountain, toward Kanouse mine.
S. 70° E.	80°	East slope of mountain, and northwest of Oakland.
S. 60° E.	60°	East slope of mountain, up 640 feet.
E. S. E.	Steep.	Top of Ramapo mountain, on section line.
S. 65° E.	Steep.	Top of mountain, west of last point of observation.
S. 70° E.	Steep.	West slope of mountain, west of above.
S. 70° E.	Nearly vertical.	Near corner of Conklintown road, Ramapo mountain.
S. 75° E.	75°	West slope of Ramapo mountain, north of last station.
Strike N 25° E	Vertical.	Near Midvale, and northeast of railroad station.
E. S. E.	Steep.	Near last point of observation.
Strike S.30° W	Vertical.	North of Blauvelt's mills, Pompton.
S. 60° E.	45°	De Bow's limestone quarry, Wanaque.
S 65° E.	45°	Near last point of observation and west of quarry.
E. S. E.	60°	Limestone, at De Bow's quarry.
S. 60° E.	60°	Gneiss, east of limestone at De Bow's quarry.
S. 80° E.	55°	" " " "
Strike N.30° E	Vertical.	Limestone, Van Houten's quarry, Wanaque.
Easterly.	35°–40°	West Brook Falls, west of Midvale.
S. 75° E.	70°	North of Macopin lake.
W. N. W.	Steep.	East of Gould quarry, Macopin.
N. 75° W.	70°	Crest of ridge, east of Cisco's quarry, West Milford.
Easterly.	55°–60°	Northwest of Butler, 1 mile.
S. 70° E.	60°	Ridge 2 miles northwest of Butler.

TABLE OF DIPS—*Continued.*

DIRECTION.	AMOUNT.	LOCALITY.
Easterly.	40°	On crest of ridge, northwest of Butler.
S. 80° E.	40°–45°	Head of ravine, 1½ miles north of Smith's mills.
S. 75° E.	45°	West of last point of observation.
Easterly.	85°	West of Long House creek, near New York line.
E. S. E.	75°–80°	On Warwick road, ½ mile south of New York line.
Easterly.	60°	Near Uttertown, west of Bearfort mountain.
N. 60°–65° W.	85°–vertical.	Near Carey's mine, west of Bearfort mountain.
S. 65° E.	85°, vertical.	¼ mile southwest of Carey's mine.
S. 80° E.	65°	Ridge southeast of Vernon.
S. 70° E.	60°	Micaceous gneiss, on ridge south of Vernon.
S. E.	15°	Pochuck mountain, near Glenwood.
E. S. E.	20°	Near last point of observation.
N. 80° E.	Nearly vertical.	Near N. Odell's, west of Glenwood.
Easterly.	Steep.	Ridge north of Odell's.
Easterly.	60°	West slope of Pochuck mountain.
N. 80° E.	50°	Top of Pochuck mountain, near Valey's.
E. S. E.	Nearly vertical.	Two Bridges.
Strike S. 35° W	Vertical.	Mountain east of Franklin Furnace.
N. 52° W.	80°	West slope of mountain, east of Franklin Furnace.
N. 52° W.	80°	Munson quarry, top of mountain, east of Franklin Furnace.
N. 30° W.	75°	S E. of limestone, Gordon's quarry, near Montville.
N. 60° W.	75°–80°	West wall of quarry, above locality.
Easterly.	60°–70°	East opening, Gordon's quarry.
N. W.	Nearly vertical.	West wall, northeast opening, Gordon's quarry.
Strike N. E.	Vertical.	Hill top, northwest of Gordon's quarry.
N. 20°–30° W.	70°	West of Brook Valley church.

The observations on the strike and dip on these section lines, show a great degree of uniformity in the direction for long distances. On Ramapo mountain, for example, the strike of the beds is remarkable for its conformity to the course of the ridges which make up this mountain mass. And the direction is north 20° east. The trend of the mountain is more nearly in a due northeast direction. The southeast border line has a course of north 38° east. These ridges run at an oblique angle to the trend of the main mountain range. The topographical map, sheet No. 4, (Northeast Highlands,) shows well this prominent feature of the surface, particularly near the southern end, east of Midvale and Wanaque and towards Pompton. West of the Wanaque valley, as well as in the valley itself, the ridges or crest lines have a general north-northeast course; whereas, southwest, and south of the Pequannock river, in Morris county, the prevailing strike, as shown by the observations of last year, is north 30° east to north 45° east. This feature of the topography as it appears in the crest lines is finely exhibited by the topographical sheet referred to above. West of the Green-Pond mountain ranges the strike is more nearly northeast, varying from north 20° east to north 40° east. On Pochuck mountain the northerly strike is again apparent, in the observations of the lists of dip and strike; and the trend of the ridges conforms to this strike. This feature of the surface is conspicuous and it attracted the attention of the survey under Dr. Kitchell, so as to be shown by a beautiful wood cut illustration in the report for 1855. That the original surface of these upraised crystalline rocks was largely determined by the position of the strata is self-evident. The changes which it has undergone in the long course of ages, through weathering and drainage and the planing down and obscuring effects of the glacial forces, have been so great that it is almost surprising to recognize any structural features in the surface they have left for our study.

From what has been observed in the field during the past season, with all the records of preceding years, it is plain that the strike in the crystalline rocks of the Highlands is nearly due northeast from the Delaware river through Hunterdon and Warren and Morris counties; in Passaic and Sussex it tends more towards the north and is north-northeast. Near the New York line it appears to be again more nearly northeast. The exceptions to these predominating courses were referred to in last year's report. The conclusion from all the observations is that the axes or lines of uplifting and folding were not straight throughout the length of the Highlands, but a little irregular, as would be expected. And the work of the past season also confirms the statements which have already appeared in these reports, that the axes of uplifts do not run longitudinally, but obliquely across the Highlands; and, consequently, the marginal lines are not in all cases parallel to the line of strike. There is no reason to suppose that the axial or folding lines along which the beds were elevated, coincided with the formation. And here it must be remembered that the extent of the crystalline or Archaean rocks is not solely what is now recognized in their outcrops, since they form the base or primitive foundation. And the present area or outcrop is but the exposed part, which has been raised into prominence by these uplifting and folding forces. The outcrops may owe their position to these forces. Besides, there are indications in the bordering formations on both sides that the elevating and folding forces were at work after the deposition of these newer rocks, so that the axial lines are traceable from the crystalline into the adjacent and overlapping sedimentary strata.

The prevailing dip is towards the southeast, although a northwest diretion is not uncommon. The angle, or amount of the inclination, is rarely less than 45°, and, in most cases, it exceeds 60°; while higher angles to vertical positions have been observed at many localities. The northwest dip may be looked upon as the reversed dips of overturned strata. The record of observations for the past season does not confirm the general statement of the last annual report, that near the outcrops of the Green-Pond mountain series the beds are less steeply inclined. At Macopin at the Gould quarry and at Cisco's quarry, both in West Milford township, the gneissic rocks dip steeply toward the northwest, or west-northwest, and are succeeded, going west, by the sandstone (Potsdam) and the magnesian limestone and then the Green-Pond mountain conglomerate, all of which dip to the northwest also, but at a little less angle. At Vernon, in Sussex county, the gneiss and Potsdam sandstone are seen in contact, and there the gneiss has a dip of 60° S. 80° E. Near the crystalline limestones of the Wanaque valley the gneissic rocks maintain their average southeast dip. Whether or not there is a slight flattening of the strata near the northwest border of the Highlands, remains unsettled. So far as has been observed, there are some very slightly tilted strata in Pochuck mountain, and much less than in the mountains east of it. But these localities seem to be very marked exceptions to the prevailing steep dip.

These observed dips do not indicate any such simple synclinal or anticlinal folds as are often seen in the newer rock formations. The only differences in the dips which have been supposed to point to folds, were seen at the DeBow limestone quarry, Wanaque. At this locality the gneissic beds on the west of the limestone belt or outcrop, dip 45° toward the southeast; whereas, on the east of the same, their inclination is at an angle of 60°. The explanation here may be that the limestone is folded closely between these enclosing gneisses, and the axis plane of the fold dips to the southeast also. Otherwise, the dips are no evidence of any folding, although the theory of many close folds relieves from the burden of accounting for the great thickness of these broad areas of uniformly southeast dipping beds. No recourse is here had to faulting, as also explanatory of the present upturned position of the strata.

The study of the rocks on these two section-lines has been limited to their composition, as recognized by the unaided eye or with the help of a common pocket lens, or, in other words, to a *macroscopical* examination of them. And no microscopical work has been done. Since the close of the season of field-work, these collections of the year and those of former years, have been examined, with reference to their more plainly marked mineralogical characters, in the hope that the rocks from the several belts, as indicated in the report for 1873, would disclose, to such a comparative examination, some distinguishing marks or differences peculiar to these belts. The occurrence of certain minerals, as accessory constituents of the rocks, or as rock-masses of limited outcrop, in the Ramapo and in the Pequest belts, has been recognized from that first attempt at a division of the formation. But these occurrences are not common characteristics of the belt. Outcrops of large size do not show any differences of this nature in their rock composition. And a representative collection from one belt might pass for that from the next or any other, on many section lines crossing the Highlands from southeast to northwest. And the study of collections appears to be most unpromising, unless they are known to be typical of the localities or belts. A collection embracing the almost endless kinds to be found in any given area, would be misleading and not properly representative, or, at least, typical. Hence the great importance of a careful study in the field of the outcrops was felt, and the attempt was made to get types as well as peculiar or uncommon mineral aggregates, in the work of the past season.

Looking over all the collections, two types or varieties are recognized as predominating. Their occurrence was noticed in the report for last year.* The light-colored or gray variety is made up principally of a pinkish to white (orthoclase) feldspar and glassy quartz, and hence approaches a granulyte in mineralogical composition. But it usually contains some mica, in the form of small brown-black scales. The feldspar is the preponderating mineral, and hence it has been called a *feldspathic gneiss.* Magnetite, hornblende, apatite, pyrite and other less common minerals enter into its composition in many cases. From chemical examinations and from the weathering, the presence of a lime-soda feldspar associated with the orthoclase, or potash feldspar, is indicated, though in the absence of any microscopic tests the feldspar species cannot all be identified. The other common variety of gneiss has been termed a *hornblendic* or *syenitic gneiss,* as hornblende is the principal mineral constituent, and, with the dark-colored mica, gives the mixture a greenish-black to black appearance. The brown-black mica seems in some cases to replace the hornblende, and the rock approaches a mica-schist, or is a micaceous gneiss. The feldspar is white, and in some specimens a triclinic species. Quartz is generally found, but in subordinate quantity. When the hornblende and feldspar make up the mass, as in some specimens, the rock becomes a quartz diorite. In consequence of these variations in the proportions of the minerals entering into its composition, it is difficult to define the type, excepting in this general way. And this variety does not appear to be as constant in its composition, or of so definite and persistent a character, as the feldspathic or granulyte variety. The broad distinction is that the one is largely orthoclase, the other hornblende, and about these two minerals the quartz, mica and triclinic feldspars range themselves as accessories. Chemical analyses of typical gneisses, made in the Survey laboratory, show that the feldspathic gneiss is largely silicious, with a comparatively small percentage of alumina, scarcely any iron oxide, less lime and magnesia, and alkalies not in excess. The hornblendic type is marked by a relatively large percentage of iron, lime and magnesia, and a deficiency in silica and in the alkalies, as compared with the feldspathic variety. The characteristic differences in their decomposition and disintegration into soils and earthy masses were referred to in last year's report. The surface earths resulting from the decay of the hornblendic rock resemble more

*Annual Report of State Geologist for 1883, pp. 31-32.

the trap-rock soils in their dark brown to red colors and their closer texture, as compared with the gray, sandy soils of the feldspathic gneiss. The greater quantity of quartz in the latter, of itself tends to make the latter a sandy mass when it falls to pieces. These marked differences in chemical composition give a hint of corresponding differences in the nature of the original sediments, and the conditions which attended their deposition. The study of the mineralogical constitution becomes a necessity, to confirm any such theories of origin which the former might indicate. It may be remarked here that in composition the crystalline rocks are like many of the newer, fragmental varieties. Shales, sandy clays and many earthy beds afford, on analysis, the same chemical constituents and in equally large percentages. It is in the crystalline structure that the marked distinction appears. And the chemical composition of our crystalline rocks becomes suggestive when studied in connection with that of newer and now forming sediments. But these rocks, like modern ones, are not of definite compositions. They are not species, as crystallized minerals, though made up of such mineral components. Hence the varying composition of the original bed or outflow is recognized in the ever-varying proportions in which the minerals appear in the crystalline mass.

It has been suggested that in the mapping of the outcrops of these typical rocks, the Highlands could be divided into areas marked by them. But it has not, thus far, been found practicable to trace the boundaries of these outcrops, since they are, in many places, so interlocked as to defy mapping, except upon maps of very large scale. And then the concealed areas come in to make the whole more confusing. But the hornblendic type does preponderate in certain parts of the territory, and, notably, on Pochuck mountain, where it is the outcropping rock over much of the surface. On Jenny Jump mountain it appears on the lower portions of the slopes; whereas the main mountain mass and the crest ledges are mostly of the feldspathic varieties. The very common association of the dark colored hornblendic gneiss with magnetic iron ore, either as *walls* or in the form of *horses of rock* in the ore body, also should be mentioned as a fact well known and recognized even among miners. This association of a ferruginous rock with an iron ore is suggestive and interesting, and may have some practical bearing.

The most important result of the field work of last autumn is the discovery of outcrops of unstratified rocks over much larger area than they had been supposed to cover. Dikes and veins of such rocks have been recognized from the first, as common in all parts of the Highlands. A large granite dike on Pochuck mountain was described by Mr. Hauessor, assistant of Dr. Kitchell, in the work of 1855. And its existence and extent were subjects of examination the past season. Smaller ones have been referred to in the Geology of New Jersey, 1868. As the bedding is so indistinct a feature in much of the gneiss, the existence of these areas of unstratified rocks was overlooked. And it is still a question how much of the so-called stratification, recognized in small outcrops by the parallelism of the mineral arrangement only, is not such, but foliation in structure. On both section-lines, which were followed across the Highlands, these outcrops of unstratified rock were observed. The rock is a rather fine-crystalline, gray syenite, though the hornblende is generally present in small quantity, and, in some specimens, is not recognized at all. Brownish black mica in small scales also appears as an accessory constituent in places, so that the rock might, perhaps, be called a hornblendic granite. Variations in the texture also come in to modify its appearance. And, as was stated above in the cases of the typical gneisses, it is not easy to give a definition applicable to the rock of all these unstratified outcrops. In consequence of the very small exposed ledges in places there was some uncertainty whether the rock was not a granitoid gneiss. The extent of this syenitic rock on the northern section line was found to be two miles across, from Upper Macopin eastward toward Midvale, or the Wanaque valley. On the other line the breadth of outcrop was about the same, and its west border was near Charlotteburgh. The granite quarry of M. J. Ryerson is in it. From the extent of the outcrops between the two sections, a belt or zone of this rock was believed to exist, although no attempt was made to trace it either northward or south beyond the Pequannock river. West of the Green-Pond mountain rocks and in the table-land of the Wawayanda mountain, there is, east from Vernon, a breadth of three miles, in which the outcrops were all found to be of a gray, hornblendic granite, approaching granulyte in its almost exclusive mixture of white feldspar and glassy quartz. The only sign of bedding noticed was in the parallelism of its minerals in some specimens. But nearly all of the glaciated ledges look like a massive rock, without any bedded structure. This unstratified rock was not found on the southern or Stockholm-Franklin section, although near Stockholm there are outcrops of syenitic and granitoid rocks. As no time was given to searches for the bounding lines of this outcrop on the Wawayanda mountain, its extent is known only so far as the section line crossed it. A subsequent study of the topography, as indicated on the maps of the atlas of New Jersey, confirms the existence of these massive rock outcrops. The crest lines, as they are shown on the map over the area east of Upper Macopin, are remarkable for their irregularity and absence of any indication of the common northeast striking ridges or hill-tops. In fact, the very unusual southeast and irregularly radiating trend of the crests east of Upper Macopin, led to an examination of the rocks there as a possible explanation of the same. East and northeast of Charlotteburgh the topography is wanting in any features of the ridge structure, excepting those due to surface-drainage and denudation. In the country east of Vernon the surface is largely made up of drift material, and this has obscured the features of structure so much that the topography, as shown by the maps, fails in evidence of any massive, unstratified rock.

The relations of these syenitic rocks to the gneisses on each side of them were not made out, as no contacts were observed. And in the absence of any evidence of superposition it cannot be said that the former are older than the stratified rocks about them or that they are eruptive masses. The scanty data collected last autumn point to the presence of these large outcrops of unstratified rocks in the northern part of the Highlands, but do not give any clew to their geological relation. Apparently confirmed by the topography, the announcement of their existence is here warranted, particularly as it is suggestive of other like areas of considerable size; and the tracing out of their boundaries may lead to a natural and easily defined division of the Archaean Highlands into granitoid and gneissic rocks.

The topographical sheets of this part of the State show not only the Macopin-Charlotteburgh area, but others also, wherein no structure, like that of long and parallel ridges or crest lines appears. For example, the table-land south of Dover and west of Morristown, extending into Mine mountain on the south and towards Chester on the west, has no drift to conceal its features, and yet it is remarkable for its nearly uniform height, except where, on its borders, the streams draining it have cut deeply into its slopes. A part of the Schooley mountain table-land also looks as if it were of such massive rock. On the contrary, the ridge structure is shown very plainly in all the Wanaque valley and southwest of the Pequannock river, from Pompton and Butler to Boonton, Rockaway and Denville. The first ridge west of Morristown, and the Fox Hill range, west of Chester, are equally prominent features. The ridges of Ramapo mountain and of Pochuck mountain have been referred to above. Other areas lacking signs of such topographical regularity or conspicuous on account of it, will be recognized on a careful examination of the maps. The existence of these areas or large outcrops of granitoid or syenitic rocks, surrounded by stratified gneisses and other crystalline rocks, gives a starting point from which to work. And it now remains to trace out their boundaries as well as study their relative positions and their constituent rocks. And to do this the geological field work must be carried forward over the whole territory as the topographic survey has gone, and properly, in advance of it. That these outcrops are not regular belts running from northeast to southwest, seems already apparent from the very little examination made of them. Their irregular shape seems hinted at by the maps. Whether they were the first land and islands around which the gneissic beds were deposited as later sediments, or were the centers of igneous action, are interesting questions, upon which it is still too early to speculate.

The rocks of the Highlands have here been called Archaean. They are also Azoic, as no remains of organisms have been found in them in the State. The presence of some serpentine-calcite limestones which look like some of the Ezoon-bearing rock of Canada, the frequent occurrence of graphite and of apatite may be taken as evidences of the existence of life forms, but as found to-day they are minerals only. The gneissic and crystalline limestone rocks resemble very closely the so-called Laurentian types of Canada. And they have been designated as Laurentian. But in the absence of any paleontological evidence by which to correlate them and prove identity, which is indicated by lithological characters, it is prudent to retain the term Archaean, as they are the oldest and first formations of which there is any evidence, older than the lowest of the Paleozoic sediments. Using this designation there cannot be the confusion or uncertainty which might come from Laurentian or Azoic.

No detailed descriptions of localities or of specimens have been given in this section on the Archaean rocks, as there have not been any facilities or time to make the proper lithological examinations, and so small a part of the territory was traversed last season. What has here been presented must be regarded partly as a short supplement to the descriptions of the last annual report, and such general statements as seemed proper to make public, not as absolutely proven, but, to some extent, preliminary and introductory to the thorough survey of the Archaean Highlands. It is a report of progress.

IX.

IRON MINES AND MINING INDUSTRY.

IRON ORE.

The work of visiting the iron mines in the northern part of the State and gathering the facts relative to their conditions of ownership, leases, length of time in active working, output, destination and markets for their ore, and other information of geological and practical nature, was assigned to George E. Jenkins, of Dover, a recent graduate of the Rutgers Scientific School, who has been familiar with mining operations on a large scale near his home. He has traversed the iron-ore district and the results of his observations and collected information are presented in the form of notes, which appear below in the list of iron mines. From these notes and from the statistics of the transporting companies, the following general statements are here inserted, introductory to the list of mines.

The general depression in business has reached the iron-mining industry and affected it very seriously. The low price of iron ore and the light demand for ore at almost any figure have caused a large shrinkage in the production and closed many of our mines. The large and increasing importations of iron ores from Spain and Africa also operate against our mines, since these rich and pure foreign ores can be put down at the furnaces near the seaboard at lower rates, per unit of metallic iron, than the New Jersey ores can be profitably mined and shipped to these same points. Besides, the adaptation of the former to the making of Bessemer iron enables them to compete successfully with our own Bessemer ores which are as yet scarcely developed.* In consequence of their superiority they are used almost exclusively for this purpose by all of the eastern Bessemer metal manufacturers and

*The imports of iron ore during the year ending June 30th, 1884, amounted to 56,488 tons from Africa; 57,664 tons from Italy, and 374,943 tons from Spain. Total iron ore imported, 553,806 tons.

there is practically no market for such home ores, nor any incentive or stimulus to the search for a development of mines of this character. The discovery of new and productive mines along the Hudson, where ore can be obtained at a minimum of cost, also makes the competition for the Pennsylvania market sharp and telling against some of our mines where the expenses of mining are relatively larger, although our magnetic ores are richer. In the face of this active competition for the market, it is evident that those mines only can hope to continue at work, where there are advantages of location, of rich and excellent ore, of ease of working and of economy in management. And it might also be added that ownership or leaseholds by furnace companies or iron manufacturers, is also a condition of profitable running since the prices in the general market are so low. As a result of this condition of things, less favorably located mines, or those which are expensive to work, or yield lean and inferior ores, must be abandoned and the capital and labor in them be turned into other channels. The work of prospecting for new locations is also almost at a stand-still. Reviewing the district it may be noted that all the mines in Passaic county are idle, so far as active, producing work is concerned; in Morris county the Hibernia, the Mount Hope, the mines in the vicinity of Dover, the Chester and the Hacklebarney mines, and the Hurd, Ford and Scofield are at work; in Warren and Hunterdon counties, or the southwestern Highlands, Kishpaugh, Oxford Furnace and West End mines are the only localities where ore in any considerable quantity has been raised; in Sussex county the Ogden mines are the sole producers. The large number of mines which have been temporarily closed or which have been abandoned is apparent on glancing over the list. Some of them may be said to have passed into history, as their period of activity has come to an end, apparently for all time.

A prominent fact indicated by these descriptive notes, is the general introduction of improved machinery for extracting and handling the ore. And much work has been done during the past year in this direction. At nearly all of the large and working mines something has been done to reduce the cost of the ore. Power-drills, explosives of higher grade, better pumps, larger engines, slopes with easier and more regular grades, shafts striking the ore more directly, and outside tracks and screens, to save so much handling and sorting the ore on the bank, all these improvements are being made in our mines, so that the mining plants are now among the best in the country. That these improvements are justifiable in the matter of economy, is already proved; that they are warranted by the probable persistence and extent of the ore bodies still unattacked, appears to be shown by the history of these larger and more productive mines, whose working period has been so long, and their aggregate product has already amounted to hundreds of thousands of tons of ore.

The total shipments of iron ore from stations in the iron ore district for the year 1884, amounted to 393,710 tons, or a deficit of 127,706 tons as compared with the amount for 1883. The decrease is about 24 per cent., or a little less than one-fourth. This shrinkage is not so bad as that of 1874, nor has the production fallen so low as it was in 1876. The outlook for the immediate future is, however, not promising of any betterment, and the depression continued through the next year (1885) will certainly reduce the total output to a lower figure. That any improvement in the business is to be looked for in the more distant future, seems warranted from a study of the past. These depressions appear to be a necessary reaction from the brisk, speculative and over-producing years, and tend to a conservatism—repressing, as they are, to all growth. But in mining, such periods are, to some extent, wholesome, in lopping off the mere speculative developments and stopping the enormous waste of energy and capital which is ever ready to embark upon mining schemes, no matter how unsubstantial they may be. And all who are familiar with the history of iron mining in New Jersey know how much has been spent in fruitless and reckless searches for ore, and in careless and wasteful methods of mining and handling these ores. The lesson of economy and retrenchment thus acquired may yet save some of our companies and build up more substantial and permanent business.

The arrangement of the list is practically the same as it was in the report for 1883. All the mines and with the references to previous notes in the Survey reports are given, as convenient for use to those who may be seeking for information about any particular locality. Excepting a few cases, no notes are made of mines which are not worked. And whenever any work of a mining character has been done, the fact has been stated. In order to make the list more interesting and serviceable as a kind of directory, the owners and lessees or operators are mentioned. A few analyses obtained from the mine authorities have been inserted.

RAMAPO BELT.

BERNARDSVILLE OPENINGS, Bernard township, Somerset county.
Ann. Reps., 1873, p. 24; 1874, p. 41.

JANES MINE, Bernard township, Somerset county.
Geology of New Jersey, 1868, p. 544; Ann. Rep., 1873, p. 24.

CONNET, or WATER STREET MINE, Mendham township, Morris county.
Ann. Rep., 1873, pp. 24–25; 1879, p. 41.

BEERS OPENING, Hanover township, Morris county.
Ann. Reps., 1878, p. 69; 1879, p. 41.

TAYLOR OPENINGS, Montville township, Morris county.
Ann. Rep., 1873, p. 25.

COLE FARM, Montville township, Morris county.
Ann. Reps., 1874, p. 21; 1879, p. 41.

KAHART MINE, Pequannock township, Morris county.
Geology of New Jersey, 1868, p. 544; Ann. Reps. 1873, pp. 25–26; 1880, p. 101.

DE BOW PLACE, Pequannock township, Morris county.
Ann. Reps., 1873, p. 26; 1879, p. 42; 1880, p. 101.

LANAGAN MINE, Pequannock township, Morris county.
Ann. Reps., 1873, p. 26; 1879, p. 42.

JACKSON, or POMPTON MINE, Pequannock township, Morris county.
Geology of New Jersey, 1868, p. 544; Ann. Reps., 1873, pp. 26–27; 1879, p. 42.

DE BOW MINE, Pequannock township, Morris county.
Ann. Reps., 1873, p. 27; 1879, p. 42; 1883, p. 82.

BEAM LOT, Pompton township, Passaic county.
Ann. Rep., 1879, p. 42.

Kanouse and Brown Mines, near Wanaque, Passaic county.

Geology of New Jersey, 1868, p. 545 (Kanouse); Ann. Reps., 1873, p. 28 (Kanouse); 1874, pp. 21–22 (Brown); 1880, p. 102; 1883, p. 82.

Sloat Farm, near Midvale, Passaic county.

Ann. Rep., 1883, p. 83.

Butler Mine, Hohokus township, Bergen county.

Geology of New Jersey, 1868, p. 544; Ann. Rep., 1879, p. 42.

PASSAIC BELT.

Large Openings, Clinton township, Hunterdon county.

Ann. Reps., 1873, pp. 28–29; 1879, p. 43.

Annandale, or Sharp Shaft, High Bridge township, Hunterdon county.

Ann. Rep., 1880, p. 102.

High Bridge, or Taylor Mine, High Bridge township, Hunterdon county.

Geology of New Jersey, 1868, pp. 617–618; Ann. Rep., 1873, p. 29; 1879, pp. 43–44; 1880, p. 102.

Silverthorn, or Kean Mine, High Bridge township, Hunterdon county.

This property is owned by Mrs. John Kean, and leased to Messrs. Large & Herry, the Silverthorn Mining Company.

The ore appears to be in large and irregularly-shaped deposits, interspersed with strings of rock and having a general northeast strike. The whole ore-breadth, or what might be termed ore-belt, is 100 feet wide. The ore at the surface is soft and red; then hard and blue, and containing much sulphur; and lean; and, at bottom, a blue ore, quite free from sulphur. But the deepest workings (80 feet) do not go far into this lower blue variety. The red ore was used at Edge Hill, Pa. At last report about 2,000 tons of ore had been mined, about half of which was on the bank. The mine is within one-quarter mile of the High Bridge Branch R. R. track.

Ann. Reps., 1879, pp. 44–45; 1880, p. 102; 1881, p. 37.

EMORY FARM, High Bridge township, Hunterdon county.
Ann. Rep., 1879, p. 45.

SHARP FARM, High Bridge township, Hunterdon county.
Ann. Rep., 1879, p. 45.

CREAGER PLACE, High Bridge township, Hunterdon county.
Ann. Rep., 1880, p. 102.

OLD FURNACE MINE, High Bridge township, Hunterdon county.
Ann. Reps., 1873, p. 29; 1879, p. 45; 1880, p. 102.

COKESBURGH MINE, Tewksbury township, Hunterdon county.
Ann. Rep., 1873, pp. 29–30.

BURRILL FARM, Tewksbury township, Hunterdon county.
Ann. Reps., 1880, p. 102; 1883, p. 84.

SUTTON FARM, Tewksbury township, Hunterdon county.
Ann. Reps., 1873, p. 30; 1879, p. 46; 1883, p. 84.

FISHER, or FOX HILL MINE, Tewksbury township, Hunterdon county.
Ann. Reps., 1873, p. 30; 1874, p. 22; 1877, pp. 49–50; 1879, p. 49.

WELCH FARM, Tewksbury township, Hunterdon county.

UPDIKE FARM, Tewksbury township, Hunterdon county.

BARTLE SHAFT, Tewksbury township, Hunterdon county.

WORTMAN SHAFT, Tewksbury township, Hunterdon county.

For notes of the Welch, Updike, Bartle and Wortman localities, see Ann. Rep., 1883, p, 85.

LANGDON MINE, Chester township, Morris county.
Ann. Rep., 1883, pp. 85–86.

PITNEY MINE, Chester township, Morris county.
Ann. Rep., 1883, p. 87.

RARICK FARM, Chester township, Morris county.

Ann. Reps., 1873, p. 31; 1879, p. 46.

HACKLEBARNEY MINES, Chester township, Morris county.

Owned by the Chester Iron Company, Richard George, superintendent.

The Hacklebarney openings have not been worked to their fullest capacity during the past year. The mine is capable of turning out 4,000 tons per month, but the production has averaged 1,500 tons, or scarcely one-half its capacity. During the past year the openings on the hill to the southwest have been connected with the High Bridge R. R., by a gravitation road, nearly 500 feet long. And a large Taylor and Langdon ore-roasting furnace has been erected at the terminus of the gravity road. These improvements facilitate greatly the handling of the ore and reduce its cost. The ore is of good quality, but contains about three per cent. of sulphur.

Geology of New Jersey, 1868, p. 557; Ann. Reps., 1873, pp. 35–36; 1879, pp. 47–49; 1880, p. 104; 1883, pp. 87–89.

GULICK FARM, Chester township, Morris county.

Owned and operated by Cooper, Hewitt & Co., S. W. George, superintendent.

The geological formation and the ore are of the same character as the Hacklebarney mines. The work of developing the property has been carried forward during the year. Three well-defined *veins* have been discovered, all having the same strike, to the northeast and the same southeast dip. The *veins* are not as wide as the Hacklebarney, but are quite as long. So far as tested they are 700 to 800 feet in length, uninterrupted. The deepest shaft is 70 feet, and drifts to the east and west, on the course of the *vein*, have been driven over 80 feet, without any indications of the ore giving out. The *vein* known as No. 1, has an average width of 12 feet; the others are narrower. During the three years that the mine has been worked, the output has been 3,000 tons a year. The ore is used at Reading, Pa. An analysis made there gives:

Metallic iron	48.0	per cent.
Phosphorus	0.47	"
Sulphur	1.50	"
Silica	0.19	"
Titanic acid	None.	

The ore is shipped by the way of the High Bridge Branch R. R.

Ann. Reps., 1873, p. 36; 1879, p. 49; 1883, pp. 89–90.

CREAGER, or PEACH ORCHARD MINE, Chester township, Morris county.

Ann. Reps. 1873, pp. 36–37; 1883, p. 90.

HEDGES MINE, Chester township Morris county.

Ann. Reps., 1873, p. 37; 1874, p. 23; 1879, p. 49.

DICKERSON FARM, Chester township, Morris county.

Ann. Reps. 1873, p. 37; 1883, p. 91.

TOPPING FARM SHAFT, Chester township, Morris county.

Ann. Reps., 1873, pp. 32–33; 1879, p. 46; 1880, p. 103; 1883, p. 91.

SAMSON MINE, Chester, Morris county.

This mine is owned by the Samson Mining Company, of Chester, N. J., and is worked under a lease, by Cooper, Hewitt & Co. S. W. George is superintendent.

The formation is of the *shoot* nature, having four well-defined walls, viz.: foot and hanging walls, which dip at an angle of 40° to the southeast; and bed and cap which pitch northeast at an angle of 20°. The length of the *vein* is 350 feet. The average depth is 300 feet. Two openings have been made on the *vein*, about 150 feet apart. The ore is "red short," and an analysis on 15,000 tons averaged:

Metallic iron	53.90	per cent.
Phosphorus	0.11	"
Sulphur	3.80	"
Silica	11.81	"

No titanic acid was found. The lime amounted to about three per cent. The mine is capable of producing about 8,500 tons of ore a year, and that amount is being mined. It is transported by way of the High Bridge Branch R. R., and goes to Reading, Pa. The well-equipped mining plant greatly cheapens the cost of production. Four 3-inch Ingersoll drills are kept going, driven by compressed air.

Geology of New Jersey, 1868, pp. 537–538 (Skellenger); Ann. Reps., 1873, p. 33 (Skellenger); 1880, p. 103; 1883, pp. 91–92.

CROMWELL MINE, Chester, Morris county.

This mine was formerly owned by the Cromwell Iron Company. It was bought in October by the Chester Highland Iron Mining Company, of 47 Broadway, New York City. O. J. Conley is the superintendent. The property adjoins that of the Samson mine, on the southwest. One *vein* is 630 feet long, and 5 shafts have been sunk. The Hunt shaft, the main outlet, is 174 feet deep. The width varies from 9 to 16 feet, averaging about 10 feet. The dip is 63° to the southeast. There is no bed-rock on the southwest, nor any cap-rock on the northeast. Since the new company has taken possession, much dead work has been done, and about $5,000 spent for mining plant. It is their intention to drive the mine to its fullest capacity—2,500 tons per month. An air compressor, capable of supplying 5 Ingersoll drills, is being erected. The ore contains from 52 per cent. to 56 per cent. of metallic iron, and little phosphorus. [See references under Samson mine, also.]

HEDGES FARM, Chester, Morris county.

Ann. Rep., 1883, p. 92.

CREAMER FARM, Chester, Morris county.

Ann. Reps., 1873, pp. 31, 33; 1883, p. 92.

HOTEL PROPERTY, Chester, Morris county.

Ann. Reps., 1873, p. 33; 1879, p. 46.

COLLIS SHAFTS, Chester, Morris county.

Ann. Rep., 1873, pp. 31, 33.

SWAYZE MINE, Chester township, Morris county.

Ann. Reps., 1873, pp. 33-35; 1879, p. 47; 1883, p. 92.

COOPER MINE, Chester township, Morris county.

The Cooper Mining Company owns and operates this mine. It has been running all the year. The searches, by means of boring, have been continued. [See Ann. Rep. for 1883, p. 93.] Hole No. 2 (1884), at an angle of 55°, struck.

At 33′ 0″	6″ of ore.
At 53′ 9″	3′ 2″ of ore.
At 63′ 4″	2′ 8″ of ore.
At 78′ 10″	9′ 0″ of ore.

Bore hole No. 3 (No. 2 of 1883), at an angle of 50°, was driven to a depth of 99 feet and 3 inches, with the following results:

At 24′ 0″	1′ 1″ of ore.
At 34′ 7″	1′ 8″ of ore.
At 82′ 0″	5′ 7″ of ore.

Hole No. 4 (No. 3 of 1883) went 118′ 7″, all in rock. Its angle of inclination was 40°. Hole No. 5, at an angle of 40°, was driven 135′ 4″, also in rock the whole distance. No. 6 was put in horizontally and in the hanging wall a distance of 35 feet—all rock. No. 7, in the opposite direction, horizontal in the foot-wall, went 68 feet—all in rock.* The problem here to be solved is the connection which these ore-bodies, found in borings, have with the shoot of ore above. Is there a hanging-wall *vein* between No. 2 and No. 3? and is there a horse of rock between this *vein* and the ore discovered in hole No. 1?

The northeast workings are continued. The dip in slope No. 3 is 65°, or more than 20° steeper than in No. 2 slope. This slope is 120 feet deep.

An analysis of the Cooper ore, by Alexander H. Sherred, gave the following:

Metallic iron	59.91	per cent.
Sulphur	3.50	"
Phosphorus	0.066	"

Another, by Booth, Garrett & Blair, gave 61.286 per cent. of metallic iron.

A Philadelphia company is erecting a roaster at the mine.

Ann. Reps., 1879, p. 47; 1880, pp. 103, 123; 1883, pp. 93, 94.

KEAN MINE, Chester township, Morris county.

Ann. Rep., 1883, p. 94.

SQUIER'S MINE, Chester township, Morris county.

Ann. Rep., 1880, p. 103.

LEAKE MINE, Chester township, Morris county.

Geology of New Jersey, 1868, p. 558; Ann. Rep. 1883, p. 94.

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*For diagram showing the ore-beds above, and the bore holes Nos. 1, 3 and 4, see Ann. Rep. of State Geologist for 1883, p. 153.

GEORGE SHAFTS, Chester township, Morris county.

Ann. Rep. 1881, p. 36 (Chester mine).

CHILD SHAFT, Chester township, Morris county.

Ann. Rep. 1883, p. 95.

HARDEN FARM, Chester township, Morris county.

Ann. Rep. 1873, p. 32.

WOODHULL MINE, Chester, Morris county.

BUDD MINE, Chester, Morris county.

Geology of New Jersey, 1868, p. 558; Ann. Reps. 1873, p. 32; 1879, p. 46; 1883, p. 95.

QUIMBY'S MINE, Chester township, Morris county.

TIGER'S MINE, Chester township, Morris county.

Ann. Rep. 1883, p. 95.

DE CAMP SHAFT, Chester township, Morris county.

DANIEL HORTON MINE, Chester township, Morris county.

BARNES MINE, Chester township, Morris county.

For previous reports of De Camp, Daniel Horton and Barnes mines, see

Geology of New Jersey, 1868, p. 558, for BARNES; also, Ann. Reps., 1873, pp. 38–39; 1879, p. 49.

LEWIS, or HERRICK MINE, Randolph township, Morris county.

Ann. Reps., 1873, p. 42; 1879, p. 50.

COMBS MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 550; Ann. Reps., 1879, p. 50; 1880, p. 104.

THORP MINE, Randolph township, Morris county.

HENDERSON MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 558.

GEORGE, or LOGAN MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, pp. 558-559; Ann. Rep., 1879, p. 49.

DAVID HORTON MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 559; Ann. Reps., 1873, pp. 39-40; 1879, p. 49.

DE HART MINE, Randolph township, Morris county.

The Progressive Iron Mining Company owns and operates this mine, and what has been called in previous annual reports the LAWRENCE MINE. S. M. Keiper is superintendent.

Many test pits have been put down and four *veins* have been discovered. They are about 400 yards long and from 3 to 9 feet wide. No cap or bed rocks have, as yet, been found. The dip is to the southeast, at angles of 80°–85°. The deepest shaft is 80 feet deep. About 40 feet of red ore lies upon the hard, blue ore. During the three years that this mine has been in operation, about 400 tons per month have been mined. It contains too much phosphorus for a Bessemer ore. All the red ore is washed in an ordinary cylindrical rotary washer. The ore is shipped on the cars at Succasunna, three miles from the mine.

Geology of New Jersey, 1868, p. 559; Ann. Reps., 1873, p. 40; 1879, p. 49; 1880, p. 104; 1883, pp. 96–97.

DALRYMPLE, or CARBON MINE, Randolph township, Morris county.

During the past year the extensive plant erected by the Crane Iron Company has been removed and shipped to Catasauqua, Pa. The only work done here has been the shipping of ore in stock; and, as stated above, the removal of the machinery. The mine, when in working order, produced nearly 2,000 tons per month.

Geology of New Jersey, 1868, p. 559; Ann. Reps., 1873, pp. 40–41; 1879, pp. 49-50; 1880, p. 104; 1883, p. 97.

TROWBRIDGE MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 559; Ann. Rep., 1879, p. 50.

SOLOMON DALRIMPLE PLACE, Randolph township, Morris county.

COOPER PLACE, Randolph township, Morris county.

MUNSON'S MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 551 (Munson's mine); Ann. Reps., 1873, p. 42; 1879, p. 50.

VAN DOREN OPENINGS, Randolph township, Morris county.

Ann. Rep., 1879, p. 50.

BRYANT MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 566; Ann. Reps., 1880, p. 104; 1883, p. 98.

CONNOR FOWLAND MINE, Randolph township, Morris county.

CHARLES KING MINE, Randolph township, Morris county.

KING MINE, Randolph township, Morris county.

McFARLAND MINE, Randolph township, Morris county.

For notes of Connor Fowland, Charles King, King and McFarland mines, see

Geology of New Jersey, 1868, pp. 566–567; Ann. Reps., 1873, p. 43; 1879, p. 50; 1880, p. 105; 1883, p. 98.

EVERS MINE, Randolph township, Morris county.

The only work done here during the year is the removal of all the machinery by the Saucon Iron Company.

Geology of New Jersey, 1868, pp. 566–567; Ann. Reps., 1873, p. 43; 1879, p. 50; 1880, p. 105; 1883, p. 98.

BROTHERTON MINE, Randolph township, Morris county.

The mine is idle, the lessees, Messrs. Pullman & George, having given up the lease.

Geology of New Jersey, 1868, p. 567; Ann. Reps., 1879, p. 50; 1880, p. 105.

BYRAM MINE, Randolph township, Morris county.

The working life of this mine seems to be at an end. The only work done here has been to clean up the surface ore and to ship the machinery to the Lower Wood mine at Hibernia.

Geology of New Jersey, 1868, pp. 567–569; Ann. Reps. 1873, pp. 43–44; 1879, p. 51; 1882, p. 70; 1883, p. 99.

BAKER MINE, Randolph township, Morris county.

This mine has been abandoned by the Crane Iron Company, and all the machinery has been sent to Catasauqua, Pa.

Geology of New Jersey, 1868, pp. 569–570; Ann. Rep., 1879, p. 52.

MILLEN MINE, Mine Hill, Randolph township, Morris county.

The machinery is now being removed to the Meadow mine, near Port Oram.

Geology of New Jersey, 1868, pp. 564–565 (Millen mine); Ann. Reps. 1879, p. 51; 1880, p. 105.

RANDALL HILL MINE, Mine Hill, Morris county.

Geology of New Jersey, 1868, p. 570; Ann. Reps., 1879, p. 51; 1880, p. 105; 1882, p. 70; 1883, p. 100.

JACKSON HILL MINE, Irondale, Morris county.

Geology of New Jersey, p. 570; Ann. Rep., 1879, p. 51.

BLACK HILLS MINE, Ferromont, Morris county.

Ann. Reps., 1879, p. 51; 1880, p. 105; 1883, p. 100.

DICKERSON MINE, Mine Hill, Morris county.

Owned by the Dickerson-Suckasunny Mining Company and operated by A. Pardee & Co. Thomas Grethaway, superintendent.

Of the three ore-shoots in this mine the side and big *veins* have been in operation all the year. The Cow Belly mine was stopped last June, owing to the dullness in the iron business. The pumps, however, are kept going and the water under control. This shoot is large, but is somewhat *stringy*, that is, considerable rock is mixed in thin layers and strings with the ore. The side *vein* is 8 feet wide, and carries the richest ore of the whole mine. A new vein was discovered last year, about 200 feet south of the pond and on the hanging wall side of the "spring vein," but the work on it was stopped before it was thoroughly tested.

The shaft near the old Dickerson mansion has been sunk to a depth of 402 feet.* The work of driving this shaft from the side *vein* to the big *vein* was begun in July, and is now over 40 feet deep. It is expected to have the shaft finished by August, 1885.

A survey made during the past year shows that the big *vein* and the Cow Belly are only 25 feet apart; they have been 125 feet apart.

*December 1st, 1884.

This approach seems to show they will unite, forming one *vein* as the mine grows deeper.

The ore of this mine is stocked at the Ferromont Railroad dump, and 25,000 tons are now ready for shipment to the Stanhope furnaces.

Geology of New Jersey, 1868, pp. 570–574; Ann. Reps., 1879, pp. 51–52; 1880, pp. 105–106; 1883, pp. 100–103.

CANFIELD PHOSPHATIC IRON ORE DEPOSIT, Ferromont, Morris county.

Ann. Reps., 1871, pp. 34–38; 1879, p. 51.

CANFIELD MINE, near Vannatta station, Morris county.

Ann. Reps., 1873, pp. 42–43; 1879, p. 52.

BAKER MINE (IN SWAMP), Vannatta station, Morris county.

Ann. Reps., 1880, p. 106; 1883, pp. 103–104.

BAKER MINE (ON HILL), Mine hill, Morris county.

Geology of New Jersey, 1868, p. 575; Ann. Reps., 1879, p. 52; 1880, p. 106; 1883, p. 104.

ERB MINE, west of Mine hill, Morris county.

SCRUB OAK or DELL MINE, west of Mine hill, Morris county.

For notes on these two mines, see

Geology of New Jersey, 1868, p. 596; Ann. Reps., 1873, p. 43; 1879, p. 54; 1880, p. 106; 1883, p. 106.

J. D. KING MINE, near Port Oram, Morris county.

Ann. Rep., 1873, p. 43.

JOHNSON HILL MINE, near Port Oram, Morris county.

Geology of New Jersey, 1868, p. 596; Ann. Reps., 1873, p. 46; 1879, p. 54.

HOFF MINE, near Port Oram, Morris county.

Owned by the Hoff estate. Operated by Oram, Hance & Co., of Port Oram. R. F. Oram, superintendent. There are two *veins* on this property, which are designated as the "hanging-wall vein" and the "foot-wall vein." A horse of rock, 10 to 14 feet thick, separates them. The strike is northeast; the dip is at an angle of 62°. The bed-rock pitches northeast, at an angle of 30° to 35°. The foot-wall *vein* averages 9 feet in width; the hanging-wall *vein*, 6 feet. The former only is now worked, and about 250 tons a month are mined. There is only 1 shaft on the *veins*. The mine has a capacity of 700 tons a month. The ore carries some phosphorus but no sulphur, and 55 per cent. metallic iron. It is considered to be an excellent, No. 1 foundry ore.

During the year that the above company has had charge, a new and well-equipped plant has been placed in position. The ore is shipped on the High Bridge Branch R. R., and goes into the general market.

Geology of New Jersey, 1868, p. 597; Ann. Reps., 1873, p. 46; 1879, pp. 54-55; 1880, p. 106; 1883, p. 107.

DOLAN MINE, Mount Pleasant, Morris county.

Owned by Bishop Dolan. Operated by Joseph Wharton, of Philadelphia. Tooke Straker, superintendent.

One shaft, close to the Mount Hope Mine R. R., goes down on the *vein* and is 140 feet deep. The dip is 60° to the southeast, and the pitch is 45° to the northeast. There are 2 *veins*, 42 feet apart. They are from 6 to 7 feet wide. The ore contains no sulphur, but has too much phosphorus for Bessemer pig-metal. It is used at Wharton's furnaces, at Port Oram and at Hackettstown. About 1,000 tons of ore have been raised.

Ann. Reps., 1873, p. 46; 1879, p. 55; 1883, p. 107.

IRONDALE MINES, Irondale, Randolph township, Morris county.

Owned by the New Jersey Iron Mining Company and operated by the Thomas and Crane Iron Companies. James Tontring superintendent.

Of this group, No. 13 shoot only is worked. There are four enclosing walls of rock; the foot and hanging walls, which are dipping 45° to the southeast, and the bed and cap-rocks, which pitch 15° to the northeast. The length of the shoot, as now worked, is 1,800 feet; and the height, that is, the distance between the cap and bed-rocks, is 140 to 150 feet; the average breadth is 7 feet. Thus far the *vein* is clean, as scarcely any rock is mined with the ore. The ore averages 61 per cent. of metallic iron and is comparatively free from sulphur. It is not a Bessemer ore. It is carted a half-mile to the High Bridge Branch R. R. at Port Oram, whence it is shipped to Catasauqua and Hockendauqua, Pa. A 16×36-inch duplex compressor has been put up and furnishes air to drive two Rand drills, four steam pumps and two hoisting engines, which are under ground. The slope goes down 400 feet to the bed-rock, 700 feet to a second summit, which point is 150 feet from the bottom. Here an engine is located, which serves to raise the ore in buckets to the car. The engine (located at the point where the slope strikes the bed-rock) then draws the car to this summit. From this point the engine on the surface pulls the car to the bank. The vertical depth of this mine is about 300 feet.

Geology of New Jersey, 1868, pp. 575–578; Ann. Reps., 1873, p. 43; 1879, pp. 52–54; 1880, p. 106; 1883, pp. 104–105.

ORCHARD MINE, Port Oram, Morris county.

Owned and operated by the estate of J. Couper Lord. Gen. J. S. Schultz general manager, and Joseph Richards mine superintendent.

This mine has not been working since March, 1884, owing to the lack of demand for ore. There is now stocked at the mine 5,369 tons.

Geology of New Jersey, 1868, p. 578; Ann. Reps., 1879, p. 54; 1880, p. 106; 1883, p. 106.

MEADOW MINE, Port Oram, Morris county.

Owned and operated by J. Couper Lord estate. Joseph Richards superintendent.

This *vein* is the same as that of the Washington Forge mine. One shaft is about 400 feet deep. The length, as now worked, is 300 feet; and the average width is 5 feet. There is neither bed nor cap-rock. The foot-wall dips 57° to the southeast. The volume of water is large, but a well-equipped plant keeps it out. The water-wheel of the Washington Forge mine is used by this mine to keep the water under control. The mine has a capacity of 2,000 tons per month. The ore contains a small percentage of phosphorus and no sulphur. It is placed on the market. It is shipped on the Mount Hope Mine R. R.

The company are now making several improvements; a 60-horse power engine and air compressor, to supply four air drills, is now being put in place; also, a large boiler.

MOUNT PLEASANT MINE.

Under the same management and ownership as the last-named mine.

And the *vein* is in the same range (or belt) as the Washington Forge and Meadow mines, but, going south, there is an off-set of 66 feet. As now worked, the *vein* is 2,000 feet long; strike is northeast; dip is 57° to the southeast; and average width is 6 feet. The ore is guaranteed at 64 per cent. metallic iron; and, on account of its richness, finds a ready market. It is very low in phosphorus, though it is not sold as a Bessemer ore. The mine has a capacity of 2,500 to 3,000 tons per month, and is kept in constant operation. An air compressor is about to be put up and power drills to be introduced, with other improvements under ground, which will reduce the cost of mining.

Geology of New Jersey, 1868, pp. 578–582; Ann. Reps., 1873, p. 44; 1879, p. 55; 1883, pp. 107–109.

BAKER MINE, near Mount Pleasant, Morris county.

Geology of New Jersey, 1868, pp. 582-583; Ann. Reps., 1873, pp. 44–45; 1879, p. 55.

RICHARD MINE, Mount Pleasant, Morris county.

Owned and operated by the Thomas Iron Company, of Hockendauqua, Pa. Reese Jenkins, superintendent.

Only 1 of the 3 *veins*, known as the "south, or hanging-wall vein," is now worked. Four openings have been made upon it, and it has been tested for a length of 2,260 feet. The deepest working is 500 feet in depth. There are 2 large offsets—1 near the Allen mine, and the other in front of Mr. Jenkins' residence. The dip is about 53° to the southeast. No cap or bed-rocks have been discovered. The ore-width varies from 1 to 25 feet. The ore breaks easily, and is mined cheaply. It averages 60 per cent. of metallic iron, and contains some phosphorus but no sulphur. The company is now mining 5,000 tons monthly, and the mine is not pushed to its fullest capacity.

Shaft No. 2 is to be converted into a slope, and a car track is to be laid from the surface to the bottom. A tunnel, 450 feet south of shaft No. 2, is to be driven in the hill so as to cut the *vein* 55 feet from the surface. This will carry off all the surface water. Air drills are used.

The other *veins* on this property have not been worked since 1872.

Geology of New Jersey, 1868, p. 583; Ann. Reps., 1873, p. 45; 1879, p. 55; 1883, pp. 109, 110.

ALLEN MINE, Rockaway township, Morris county.

Owned by the New Jersey Iron Mining Company. L. C. Bierwirth, of Dover, manager.

Some work was done here—cross-cutting for the main Richards *vein*—but without success. It is now idle.

Geology of New Jersey, 1868, pp. 583–587; Ann. Reps., 1873, p. 45; 1879, pp. 55–56; 1883, pp. 110–111.

TEABO MINE, Teabo hill, Rockaway township, Morris county.

Owned and worked by the Glendon Iron Company. George Richards, manager.

There are three shoots of ore, one over the other, the bed-rock of one shoot being the cap-rock of the shoot below. These shoots are about 45 feet high. The bed-rock pitches to the northeast at an angle of 21°; the foot-wall dips 70° to the southeast, and the strike is northeast. The top shoot is worked to a length of 1,057 feet without striking rock; the middle shoot a length of 797 feet, and the lower shoot a distance of 150 feet. The average width of the top shoot is 5 feet, of the middle shoot 16 feet, and that of the lower shoot 18 feet. The capacity of the mine is about 20,000 tons a year, and that amount is being taken out.

Geology of New Jersey, 1868, pp. 587–588; Ann. Reps., 1873, p. 45; 1879, p. 56; 1883, p. 111.

MOUNT HOPE MINES.

Owned and operated by the Mount Hope Mining Company (Lackawanna Iron and Coal Company). Matson Williams, superintendent and manager.

No changes in the *veins* have been observed since the last annual report. The dullness of the iron market has had the effect of greatly diminishing the output of these mines. During the year preparations have been made to increase the productiveness of the Stevens Shaft. A double skip track is being put in, and the mine is connected with the docks at the mouth of the tunnel by a gravitation railroad.

Geology of New Jersey, 1868, pp. 588–595; Ann. Reps., 1873, pp. 45–46; 1879, p. 56; 1880, p. 107; 1883, pp. 112–113.

DENMARK MINE, near Denmark, Morris county.

Geology of New Jersey, 1868, p. 597.

GREENVILLE MINE, Greenville, Rockaway township, Morris county.

CHESTER IRON COMPANY'S OPENINGS, near Copperas mountain, Morris county.

For notes of these two mines, see

Ann. Reps., 1873, p. 48; 1879, p. 58; 1883, pp. 113, 114.

DAVENPORT MINE, Rockaway township, Morris county.

James Davenport, owner; leased by the Mutual Iron Company. Edward George, superintendent.

This mine stopped working in April, 1884. The *vein* is 400 to 500 feet long, and is worked by means of an open cut and one shaft 90 feet deep. The ore width is from 7 to 8 feet.

Ann. Reps., 1880, pp. 122–123; 1883, p. 114.

PARDEE MINE, Rockaway township, Morris county.

This mine is owned by the Mutual Iron Company, and it was worked up to December 1st.

WINTER'S MINE, Rockaway township, Morris county.

The mining work on this property was on a new deposit. It stopped before the testing had been fully done. Work is to be resumed in the spring.

The ore from these mines (Winter, Pardee and Davenport) is shipped via the Green Pond R. R. to Charlotteburgh; thence on the New York, Susquehanna and Western R. R.

For notes of Pardee, Winter and Davenport mines, see

Ann. Reps., 1873, p. 48 (Pardee and Canfield mines); 1880, pp. 122–123; 1883, p. 114.

GREEN POND MINES, Rockaway township, Morris county.

Ann. Reps. 1873, pp. 48–49; 1874, pp. 23–25; 1879, pp. 58–60; 1880, p. 108.

HOWELL TRACT OPENINGS, near Charlotteburgh, Morris county.

KITCHELL TRACT OPENINGS, near Charlotteburgh, Morris county.

For notes of the openings on Howell and Kitchell tracts, see

Ann. Reps., 1879, p. 60; 1880, p. 108.

CHARLOTTEBURGH MINE, Charlottebūrgh, Morris county.

Owned by Cooper, Hewitt & Co., and worked by the owners. Edward George, superintendent.

This mine has been worked by the owners during the year, but no ore has been shipped recently.

Geology of New Jersey, 1868, p. 596; Ann. Reps., 1873, p. 49; 1879, p. 60; 1880, p. 108; 1883, p. 115.

SWEDES MINE, Rockaway township, Morris county.

Geology of New Jersey, 1868, pp. 551–554; Ann. Reps., 1873, pp. 46–47; 1879, p. 56.

SIGLER MINE, Rockaway township, Morris county.

WHITE MEADOW MINE, Rockaway township, Morris county.

GIBB MINE, Rockaway township, Morris county.

BEACH MINE, Rockaway township, Morris county.

For notes of these four mines, see

Geology of New Jersey, 1868, pp. 559–560; Ann. Reps., 1873, pp. 46–47; 1879, p. 56.

HIBERNIA MINES, Hibernia, Rockaway township, Morris county.

The Lower Wood Mine, owned by the New Jersey Iron Mining Company, and operated by the Andover Iron Company, has been running all the year. No. 1 pump shaft has been converted into a slope, and a skip track runs down obliquely on the foot wall, which has a dip of 65°. The slope is about 500 feet long. Only 3,200 tons a month have been mined.

The Glendon, De Camp, Scott and Upper Wood lots have been worked by the Glendon Iron Company.

The Willis mine, leased by the Bethlehem Iron Company, is not working.

The Glendon Iron Company has its dock stocked with ore. The underground railway is being continued across the Hibernia stream to the side hill, where new docks are being built. The new structure is nearly 1,000 feet long. And screens are being put up, by which the coarse and fine ores are to be separated.

The shipments of ore from the Hibernia mines in 1884, amounted to 59,681 tons, or but little over 60 per cent. of the totals for 1883.

Geology of New Jersey, 1868, pp. 561–564; Ann. Reps., 1873, p. 47; 1879, pp. 56–57; 1880, p. 108; 1883, pp. 116–117.

BEACH GLEN MINES, Beach Glen, Rockaway township, Morris county.

Owned by the J. Couper Lord estate. General J. S. Schultze, manager.

This mine has been working up to within three months. The pumps are kept going.

The main *vein* is opened upon by a tunnel 1,400 to 1,600 feet long on the line of strike. This tunnel intersects the shaft at 106 feet below the surface. The mine is 200 feet deep. The *vein* is 10 feet wide. The ore gives 45 per cent. of metallic iron on analysis, and finds a ready market, as it is a Bessemer ore.

Geology of New Jersey, 1868, pp. 554–556; Ann. Reps., 1879, p. 57; 1883, p. 118.

MERIDEN MINE, Meriden, Morris county.

RIGHTER MINE, near Meriden, Morris county.

COBB MINE, near Splitrock pond, Morris county.

Notes of Meriden, Righter and Cobb mines in

Geology of New Jersey, 1868, p. 556 (Meriden mine); Ann. Reps., 1873, p. 47; 1879, p. 57; 1880, p. 108.

SPLITROCK MINE, head of Splitrock pond, Morris county.

Ann. Reps., 1873, pp. 47–48; 1874, p. 23; 1879, pp. 57–58; 1880, p. 108.

WOOD MINE, north of Splitrock pond, Morris county.

Ann. Rep., 1883, pp. 118–119.

BOTTS' MINE, Rockaway township, Morris county.

ROCKAWAY VALLEY MINE, Rockaway township, Morris county.

DECKER FARM OPENING, Rockaway township, Morris county.

For notes of Botts', Rockaway Valley and Decker mines, see

Ann. Reps., 1873, pp. 49–51; 1879, p. 60; 1880, p. 109; 1883, p. 119.

GOULD MINE, Rockaway township, Morris county.

PIKE'S PEAK MINE (Stony Brook mine), Rockaway township, Morris county.

RIGHTER LOT OPENING, Rockaway township, Morris county.

References for the Gould, Pike's Peak and Righter in

Geology of New Jersey, 1868, p. 556 (Stony Brook mine); Ann. Reps., 1873, p. 51; 1876, pp. 54–55 (Stony Brook mine); 1879, pp. 60–61; 1880, p. 109.

VREELAND MINE, near Charlotteburgh, Passaic county.

Ann. Rep., 1879, p. 61.

WANAQUE MINES, Pompton township, Passaic county.

Geology of New Jersey, 1868, pp. 545–546 (Wynokie); Ann. Rep. 1873, p. 52 (Wynokie).

PELLINGTON MINE, Pompton township, Passaic county.

RHEINSMITH MINE, Pompton township, Passaic county.

MONKS MINE, Pompton township, Passaic county.

Ann. Reps., 1873, p. 52 (Monks mine); 1874, pp. 25–26 (Pellington mine, Rheinsmith farm); 1879, p. 61.

WRIGHTNEOUR MINE, west of Monks station, Passaic county.

Ann. Rep., 1881, p. 36.

BOARD MINE, near Monks station, Pompton township, Passaic county.

This mine is now idle, but was in operation the greater part of the year. The lessee, Joseph L. Cunningham, has over 4,000 tons of ore in stock at the mine. The stoppage was owing to the dullness of the iron ore market.

Ann. Reps., 1873, p. 52; 1879, p. 61; 1883, p. 120.

RINGWOOD MINES, Ringwood, Passaic county.

Owned by Cooper, Hewitt & Co. Phillip George, superintendent. This well-known mining property also has felt the effect of a weak iron market.

Three openings, known as the New Miller, New or Little Peters, and Old Peters, have been worked. The New Miller mine is about 140 feet deep. The shoot is about 300 feet long, 30 feet high and an average width of 12 feet. It appears now to be getting smaller. The New Peters shoot is 20 feet high, and averages 10 feet in width. The Old Peters shoot is 70 feet high and 30 feet wide. Another shoot of ore has been opened in the swamp, in range with the Old Peters. As there was no market for the ore, operations were suspended.

While at work about 2,000 tons of ore were mined monthly. But during the past two months no ore has been raised.

The ore is fine grained and rich, and contains no sulphur, but the phosphorus amounts to one-half of one per cent. It is shipped to the furnaces of the owners at Durham, Pa., via the New York and Greenwood Lake Railroad.

Geology of New Jersey, 1868, pp. 546–550; Ann. Reps., 1873, pp. 52–54; 1880, p. 109.

MUSCONETCONG BELT.

HAGER MINE, Holland township, Hunterdon county.

DUCKWORTH OPENINGS, Holland township, Hunterdon county.

BLOOM FARM, Holland township, Hunterdon county.

MARTIN FARM, Alexandria township, Hunterdon county.

None of these localities have been worked during the year. For previous notices of them, see

Ann. Reps., 1875, p. 35 (Bloom); 1879, pp. 62–63; 1880, p. 109; 1883, p. 122.

PETTY FARM, Bethlehem township, Hunterdon county.

WRIGHT FARM, Bethlehem township, Hunterdon county.

CASE FARM, Bethlehem township, Hunterdon county.

These three localities also are idle. For descriptions, see

Ann. Rep., 1880, p. 123.

CHURCH or VAN SYCKLE'S MINE, Bethlehem township, Hunterdon county.

Geology of New Jersey, 1868, p. 616; Ann. Reps, 1873, p. 55; 1879, p. 65.

TURKEY HILL or WEST END MINES, near Valley Station, Hunterdon county.

Owned and operated by the West End Iron Company. G. M. Miller, superintendent.

Mining work stopped at these mines last July, since which time the pumps have been kept going.

Five openings have been made upon the *vein*, which is over a half a mile in length, striking to the northeast, and the deepest is 290 feet deep. The foot wall dips 65°–70° to the southeast; the bed rock pitches to the northeast at an angle of 45°. The average width of the ore is 12 feet. In No. 1 shaft a roll in the hanging wall has increased the width to 35 feet; the foot wall continuing on its regular dip. The ore averages 50 per cent. of metallic iron, and, being low in phosphorus and sulphur, is suited to the manufacture of Bessemer pig. It is used by the Lackawanna Iron and Coal Company, at Scranton, Pa.

SWAYZE MINE, near Valley Station, Hunterdon county.

This mine also is owned and operated by the West End Iron Company.

The *vein* is supposed to be the same as that of the Turkey Hill mines. The pitch is a little steeper. During the past year an offset has been met with, throwing the *vein* to the northeast (along the strike) about 40 feet. Beyond this offset two drifts have been driven into ore, about 300 feet. The total length of the workable stopes is 467 feet.

The wire tramway is in successful operation.

About 15,000 tons of ore have been taken out of both the Turkey Hill and the Swayze mines during the year. The capacity is considered to be at least 3,000 tons per month.

Notes of Turkey Hill and Swayze mines in

Ann. Reps., 1874, p. 27 (Broderick and Harris mines); 1879, pp. 63–64; 1880, pp. 109–110; 1883, p. 123.

ALPAUGH FARM, Bethlehem township, Hunterdon county.

WILDCAT MINE, Bethlehem township, Hunterdon county.

RODENBAUGH MINE, Bethlehem township, Hunterdon county.

For notes of Alpaugh, Wildcat and Rodenbaugh, see
Ann. Reps., 1879, p. 65; 1880, p. 110.

ASBURY MINE, Bethlehem township, Hunterdon county.
Geology of New Jersey, 1868, p. 617; Ann. Reps., 1879, pp. 65-66; 1880, p. 110.

MILLER FARM, Bethlehem township, Hunterdon county.
Ann. Rep., 1879, p. 66.

MABERRY PLACE, Bethlehem township, Hunterdon county.
Ann. Reps., 1873, p. 56; 1879, p. 66; 1880, pp. 110 and 124.

BANGHART'S MINE, Lebanon township, Hunterdon county.
Geology of New Jersey, 1868, p. 617; Ann. Rep., 1879, p. 66.

EVELAND MINE, Glen Gardner, Hunterdon county.
Ann. Rep., 1880, pp. 110 and 124.

TERRABERRY MINE, White Hall, Hunterdon county.
Ann. Rep., 1879, p. 66.

ALVAH GRAY OR SAND FLATS MINE, White Hall, Hunterdon county.
Ann. Reps., 1879, p. 66; 1880, p. 124.

WHITE HALL (FRITTS FARM), White Hall, Hunterdon county.
Ann. Rep., 1873, p. 56.

CASTNER FARM, Lebanon township, Hunterdon county.
Ann Reps., 1873, p. 56; 1879, p. 66.

MATTISON OPENINGS, near Andersontown, Hunterdon county.
Ann. Rep., 1880, p. 124.

HUNT, or PIDCOCK MINE, Lebanon township, Hunterdon county.
Ann. Reps., 1873, p. 56; 1879, p. 66; 1880, p. 111.

SHARP'S MINE, Pleasant Grove, Schooley's mountain, Morris county.

HANN MINE, Pleasant Grove, Schooley's mountain, Morris county.

Notes of Sharp's and Hann mines in

Ann. Reps., 1873, pp. 56, 57; 1879, pp. 66–67; 1880, p. 111.

DERRENBERGER FARM, Schooley's mountain, Morris county.

Ann. Rep., 1883, p. 125.

STOUTENSBURG MINE, Schooley's mountain, Morris county.

Ann. Reps., 1873, pp. 57–58; 1879, pp. 67–68; 1880, p. 111.

FISHER, or BEATTYESTOWN MINE, Schooley's mountain, Morris county.

Geology of New Jersey, 1868, p. 618; Ann. Rep. 1879, p. 68.

MARSH'S MINE, Schooley's mountain, Morris county.

Geology of New Jersey, 1868, pp. 618–619; Ann. Reps., 1879, pp. 68–69.

DICKINSON'S MINE, Schooley's mountain, Morris county.

Geology of New Jersey, 1868, pp. 619–620.

HUNT FARM, Schooley's mountain, Morris county.

Ann. Rep., 1879, p. 69.

LAKE FARM, Schooley's mountain, Morris county.

Ann. Rep., 1879, p. 69.

NAUGHRIGHT MINE, near Naurightville, Morris county.

Ann. Reps., 1873, pp. 58–59; 1878, pp. 99–100; 1879, p. 69; 1880, p. 111; 1883, p. 126.

SHARP FARM, Schooley's mountain, Washington township, Morris county.

RARICK FARM, Schooley's mountain, Washington township, Morris county.

HOPLER FARM, Schooley's mountain, Washington township, Morris county.

For notes of Sharp's, Rarick and Hopler, see

Ann. Reps., 1873, p. 59; 1879, p. 69.

POOLE PLACE, near Draketown, Schooley's mountain, Morris county.

Ann. Rep., 1880, p. 112.

SHOUSE TUNNEL, east of Hackettstown, Morris county.

CRAMER MINE, east of Hackettstown, Morris county.

Ann. Reps., 1877, p. 49; 1879, p. 70.

APPLEGET FARM, Mount Olive township, Morris county.

Ann. Rep., 1880, p. 125.

SMITH'S MINE, Mount Olive township, Morris county.

Geology of New Jersey, 1868, pp. 620–621; Ann. Rep. 1879, p. 70.

LAWRENCE MINE, Mount Olive township, Morris county.

MOUNT OLIVE MINE, Mount Olive, Morris county.

The Mount Olive mines are owned by the heirs of Aaron Solomon, John Drake and Jacob Yeager. They are leased by the Mount Olive Iron Company. William E. George, of Dover, president and general manager.

The developments upon the *vein* show it to be about 400 feet long. The deepest working is 175 feet. The *vein* is 14 feet wide, and the ore is very rich. A new shoot of ore was discovered this year, not in the same course as the old workings. The new slope is being sunk down so as to strike this shoot, and machinery is being put up to work the mine to its fullest capacity. The output during the past year amounted to 6,000 tons.

Geology of New Jersey, 1868, pp. 599–601; Ann. Reps., 1873, p. 59; 1879, p. 71; 1883, p. 127.

DRAKE'S MINE, Mount Olive, Morris county.

OSBORN'S MINE, Mount Olive, Morris county.

HILT'S MINE, Mount Olive, Morris county.

BAPTIST CHURCH MINE, Mount Olive, Morris county.

For previous notes of these Mount Olive mines, see

Geology of New Jersey, 1868, pp. 599–601; Ann. Reps, 1873, p. 59; 1879, pp. 70–71; 1880, p. 112; 1883, p. 127.

KING MINE, near Drakeville, Morris county.

HIGH LEDGE MINE, near Drakeville, Morris county.

Ann. Reps., 1879, p. 71; 1880, pp. 124–125; 1883, pp. 127–128.

MARIOT'S MINE, near Shippenport, Morris county.

GOVE MINE, near Shippenport, Morris county.

Ann. Reps., 1879, p. 71; 1880, p. 112: 1883, p. 128.

BURT MINE, Drakeville, Morris county.

Ann. Rep., 1883, p. 128.

SILVER SPRING MINE, near Lake Hopatcong, Morris county.

Ann. Rep., 1883, p. 128.

DAVENPORT MINE, near Berkshire valley, Morris county.

Geology of New Jersey, 1868, p. 602.

LAKE VIEW MINE, near Lake Hopatcong, Morris county.

Ann. Rep., 1883, p. 129.

NOLAND'S MINE, Lake Hopatcong, Morris county.

Geology of New Jersey, 1868, p. 603.

HURD MINE, Hurdtown, Morris county.

Owned by the Hurd estate. Leased by the Glendon Iron Company. The mine has been in operation all the year; but mostly dead-work, putting in new pumps, &c. The slope, which goes down on the bed-rock, is now 2,200 feet long, and the bottom of the mine is 947 feet deep below the mouth of the shaft,* or down about to the ocean level, being the deepest mine in the State. The walls are about vertical. The pitch is 32°, and is northeast. The shoot is 90 feet high, and has an average width of 30 feet. In June, an offset threw the *vein* on the northeast, into the hanging-wall, over 16 feet. The output for the year 1884 has been 1,800 tons per month. Up to December 1st, 21,223 tons were in stock at the mine. The ore is rich, averaging 65 per cent. of metallic iron, containing some sulphur and a little phosphorus. It is shipped over the Ogden Mine railroad and the Central Railroad of New Jersey.

Geology of New Jersey, 1868, pp. 606–610; Ann. Reps., 1873, p. 65; 1879, p. 72; 1883, pp. 129–130.

LOWER WELDON MINE, Jefferson township, Morris county.

Ann. Reps., 1873, p. 65; 1879, p. 72.

* These figures are from a survey made recently.

WELDON MINE, Jefferson township, Morris county.

Geology of New Jersey, 1868, pp. 610–612; Ann. Reps., 1873, p. 65; 1879, p. 72; 1880, p. 112; 1883, p. 130.

DODGE MINE, Jefferson township, Morris county.

Owned by Phelps, Dodge & Co. Wm. Allen Smith, of New York City, general manager.

This mine was worked until July, when it was closed on account of the dullness of the iron market.

Geology of New Jersey, 1868, p. 614; Ann. Reps., 1879, p. 72; 1880, p. 112; 1883, p. 131.

FORD MINE, Jefferson township, Morris county.

Owned by the Musconetcong Iron Company. Thomas Trethaway, superintendent.

There are two *veins* on this property, known as the "Ford vein" on the foot-wall side, and the "Glendon vein" on the hanging-wall side. A horse of rock, 22 feet wide, separates them. As the mine goes deeper, this horse of rock diminishes in width, and at the bottom it is only 9 feet wide. The main outlet of the mine is the "hill shaft," which is now 240 feet deep. This shaft proved the Glendon *vein* to be a large deposit, having eastern and western stopes 400 feet long, and averaging 9 to 12 feet wide. This shaft was located to come down upon the horse of rock, and, by means of a door in the side, the bucket is made to go into either of the *veins*.

The ore has been removed from the Ford mine to a depth of 240 feet, and the *vein* now measures 12 to 15 feet in width. No cap or bed rocks have been discovered, for when the *vein* narrows to 2 feet or less it is not worked. The ore is of excellent quality, but containing too much phosphorus for Bessemer purposes. The sulphur is removed by roasting, at Stanhope, to which point the ore is shipped, over the Ogden Mine and the Delaware, Lackawanna and Western Railroads. The mine was idle up to July, since which time it has been in continuous operation. The capacity is fully 30,000 tons a year.

Geology of New Jersey, 1868, pp. 614–616; Ann. Reps., 1873, p. 66; 1879, p. 72; 1880, p. 113; 1883, p. 131.

SCOFIELD MINE, Jefferson township, Morris county.

Owned and operated by the Crane Iron Company, of Catasauqua, Pa. David Jenkins, agent.

The Scofield mine adjoins the Ford mine on the northeast. It was re-opened in 1879, when the bottom of the mine was in rock, and, after driving through a rock 92 feet, a new shoot of ore was discovered. This shoot has been tested by two sinks, and the stopes beaten away. The bed rock of the "old Scofield" shoot, 86 feet from the surface, is the cap rock of the "new shoot," which has a pitch to the northeast, at an angle of 60° to 65°. The old shoot dips 79° to the southeast. The new shoot is vertical.

The "old vein" is 278 feet from the surface, and the bed rock has thrown the *vein* to the northeast, so that it is now 100 feet from the shaft.

The "old vein" is not now worked. It is about 110 feet high, and from 4 to 6 feet wide. The ore is from 63 to 65 per cent. of metallic iron. The total depth of the mine is now 383 feet. The height of the "new shoot" is not known, as the bed rock has not been discovered. It averages 10 feet wide. The western stope is 110 feet long where it goes over on the property of A. Pardee & Co. This *vein* is supposed to be what is known as the "Glendon vein" in the Ford mine. In hopes of finding the "Ford vein," cross-cuts were driven into the foot and hanging walls, but without success. The ore in this "new shoot" does not seem to be as rich as the "old shoot," but the *vein* is still in a process of development. Thus far the analysis averages 50 to 54 per cent. of metallic iron. The capacity of the mine is easily 2,000 tons per month.

Geology of New Jersey, 1868, p. 615; Ann. Reps., 1879, pp. 72–73; 1880, p. 113; 1883, p. 131.

GOBLE MINE, Jefferson township, Morris county.

BOSS MINE, Jefferson township, Morris county.

FRASER MINE, Jefferson township, Morris county.

DUFFEE MINE, Jefferson township, Morris county.

SHONGUM MINE, Jefferson township, Morris county.

For notes of Goble, Boss, Fraser and Shongum, see
Geology of New Jersey, 1868, pp. 612–614; Ann. Rep., 1873, p. 66.

MINE NEAR WOODPORT, Morris county.
Ann. Rep., 1883, p. 132.

CLINE OPENINGS, Pohatcong mountain, Franklin township, Warren county.

SMITH OPENINGS, Pohatcong mountain, Franklin township, Warren county.

DEAN OPENINGS, Pohatcong mountain, Franklin township, Warren county.

For Cline, Smith and Dean, see

Ann. Rep., 1879, p. 73.

CARTER MINE, near Stewartsville, Greenwich township, Warren county.

Ann. Rep., 1880, p. 125 ("Willever & Godfrey mine").

CHAPIN AND LOMMASSON TUNNEL, near Oxford Furnace, Warren county.

Ann. Rep., 1873, p. 60.

OXFORD FURNACE MINES, Oxford Furnace, Warren county.

Owned and operated by the Oxford Iron and Nail Company.

1. Lanning mine. The ore deposit is of the pocket formation, and has a length of 150 feet, and is from 2 to 16 feet wide. The mine was stopped in the spring.

2. Car-wheel mine. This mine has not been worked since 1880.

3. Washington mine. About twenty years ago this mine was abandoned, owing to the sulphurous nature of the ore. It was re-opened five or six years ago, and kilns for roasting the ore were erected. The deposit is 900 feet long, and has an average width of 11 feet. It is 200 feet deep. The strike is southeast to northwest, the pitch to the northwest, and the dip 70° to the southwest.

4. Slope No. 3. This opening is on the Car-wheel *vein*.

The capacity of the Oxford mines is 30,000 tons a year. Only 19,564 tons were taken out in 1884. The ore contains very little phosphorus, but considerable sulphur. The average yield of metallic iron is 55 per cent. A tramway, one-half mile long, connects the mines with the furnaces.

Geology of New Jersey, 1868, pp. 637–640; Ann. Reps., 1873, pp. 60–61; 1879, pp. 74, 96; 1880, p. 113; 1883, p. 138.

CREAGER MINE, near Port Murray, Warren county.

MITCHELL MINE, near Port Murray, Warren county.

JOHNSON SHAFTS, near Port Murray, Warren county.

STEPHENSON MINE, near Port Murray, Warren county.
Notes of Port Murray mines in
Ann. Reps., 1878, pp. 61-62; 1879, p. 75; 1880, p. 113.

BALD PATE MINE, north of Port Murray, Mansfield township, Warren county.

SHAFER, or WELCH PLACE, north of Port Murray, Mansfield township, Warren county.

EGBERT CHURCH MINE, north of Port Murray, Mansfield township, Warren county.
Geology of New Jersey, 1868, p. 624 ("Bald Pate mine"); Ann. Reps. 1878, p. 62; 1879, pp. 75-76; 1880, p. 113.

SEARLE MINE, Independence township, Warren county.
Geology of New Jersey, 1868, p. 624.

BARKER, or BULGIN MINE, near Vienna, Warren county.
Ann. Rep., 1882, p. 72.

BUCK'S HILL OPENINGS, near Hackettstown, Warren county.

DAY MINE, near Hackettstown, Warren county.

FRACE FARM, north of Hackettstown, Warren county.

YOUNG FARM, north of Hackettstown, Warren county.

PYLE FARM, north of Hackettstown, Warren county.

AXFORD FARM, north of Hackettstown, Warren county.

BRYANT MINE, near Warrenville, Warren county.

EXCELSIOR MINE, Allamuchy township, Warren county.

EUREKA MINE, Allamuchy township, Warren county.

TUNISON PLACE, Allamuchy township, Warren county.

WINTERMUTE FARM, Allamuchy township, Warren county.

HAGGERTY'S MINE, Allamuchy township, Warren county.

A long list of localities, scarcely any of which have been explored and opened sufficiently to deserve the designation of *mines;* and, so far as known, all of them are idle at present. In a number of them the ores are lean, properly magnetite in rock, both stratified and massive; in some of them the veins are too narrow for profitable working. In the few out of the whole number which have produced ore in quantity, the distance from transportation would make the ore cost too much when the markets are so depressed as during the past year.*

Ann. Reps., 1873, pp. 63–64; 1876, p. 52 (Haggerty's mine); 1879, p. 76 (Haggerty's mine); 1880, p. 127 (Wintermute's farm).

BROOKFIELD, or WATERLOO MINE, near Waterloo, in Warren county.

This mine is worked by the West End Iron Co., G. M. Miller, Superintendent. The *vein* is said to average four to five feet in width.

Geology of New Jersey, 1868, pp. 626–628; Ann. Reps., 1873, pp. 64–65; 1879, p. 76.

FRENCH'S PLACE, Byram township, Sussex county.

Ann. Reps., 1873, pp. 66–67; 1879, p. 77.

SMITH, or CASCADE MINE, Byram township, Sussex county.

Ann. Reps., 1873, p. 66; 1879, p. 77; 1883, p. 135.

ALLIS OPENINGS, Byram township, Sussex county.

Ann. Reps., 1873, p. 66; 1879, p. 77.

HUDE, or STANHOPE MINE, near Stanhope, Sussex county.

Geology of New Jersey, 1868, pp. 622–623; Ann. Reps., 1873, p. 67; 1879, pp. 77–78; 1880, p. 114.

WRIGHT, or BUDD MINE, near Stanhope, Sussex county.

Ann. Reps., 1879, pp. 78–79; 1880, p. 114.

SILVER MINE, near Stanhope, Byram township, Sussex county.

HAGGERTY MINE, near Stanhope, Byram township, Sussex county.

LAWRENCE MINE, near Stanhope, Byram township, Sussex county.

Notes of these three mines in

Geology of New Jersey, 1868, pp. 621–622; Ann. Rep., 1873, p. 67.

* From report of 1883.

LAWSON OPENING, near Byram cove, Byram township, Sussex county.

Ann. Rep., 1880, p. 127 (Lawless).

GAFFNEY MINE, Byram township, Sussex county.

SICKLES MINE, Byram township, Sussex county.

Ann. Reps., 1873, p. 67; 1879, p. 79; 1880, p. 115; 1883, p. 136.

SHERMAN FARM OPENINGS, east of Sparta, Sussex county.

BUNKER FARM OPENINGS, east of Sparta, Sussex county.

For Bunker and Sherman, see

Ann. Rep., 1879, pp. 79–80.

OGDEN MINES, Sparta township, Sussex county.

The mines in this group are all located on one shoot of ore. The pitch—25° to the northeast—has carried the ore over on to the Pardee mine lot. This mine (Pardee) is owned by the Ogden Mine Railroad Company, and is leased to the Musconetcong Iron Company, of Stanhope. The shoot is carried 110 feet high. The dip is nearly vertical. The cap rock has not been discovered. One shaft goes down upon the *vein*, and is 375 feet deep. The average width is 15 feet. The ore is free from sulphur, but is not suitable for Bessemer pig. It is used at Stanhope and at the Allentown rolling mills.

The mine has been in steady operation for the past 7 years. The water is very strong, but is controlled by good machinery and pumps. The capacity is 20,000 tons yearly.

Geology of New Jersey, 1868, pp. 631–632; Ann. Reps., 1873, p. 68; 1879, p. 80; 1880, p. 115; 1883, p. 137.

GREER FARM OPENINGS, Hardyston township, Sussex county.

HOPEWELL FORGE TRACT, Hardyston township, Sussex county.

Ann. Reps., 1873, p. 68 (Greer and Hopewell); 1879, p. 80 (Greer and Hopewell); 1881, p. 38 (Greer and Hopewell).

CANISTEAR MINE, Vernon township, Sussex county.

TRACY AND CRANE FARMS, Vernon township, Sussex county.

HENDERSON FARM, Vernon township, Sussex county.

For notes of these three localities, see

Ann. Reps., 1873, p. 70; 1879, p. 80; 1880, p. 115.

WILLIAMS MINE, Williamsville, Vernon township, Sussex county.

Ann. Reps., 1873, p. 70; 1879, p. 80; 1883, p. 138.

RUTHERFORD TRACT OPENINGS, Vernon township, Sussex county.

HUNT TRACT OPENINGS, Vernon township, Sussex county.

For Rutherford and Hunt, see

Ann. Reps., 1873, pp. 70–71; 1879, p. 80.

WAWAYANDA MINE, Vernon township, Sussex county.

GREEN MINE, Vernon township, Sussex county.

These mines of the Thomas Iron Company have been described in

Geology of New Jersey, 1868, pp. 632–637; Ann. Reps., 1873, p. 71; 1880, p. 115.

LAYTON MINE, near New Milford, in Vernon township, Sussex county.

Ann. Rep., 1883, p. 139.

KIMBLE FARM SHAFTS, near Stockholm, West Milford township, Passaic county.

BUDD & HUNT TRACT OPENINGS, West Milford township, Passaic county.

RUTHERFORD TRACT OPENINGS, West Milford township, Passaic county.

CLINTON TRACT MINE, near Clinton, West Milford township, Passaic county.

WALLACE MINE, north of Clinton, West Milford township, Passaic county.

UTTER MINE, Uttertown, West Milford township, Passaic county.

For notices of these mines in West Milford township, see

Ann. Reps., 1873, pp. 68-69; 1879, pp. 81–82.

WELLING MINE, near Greenwood, West Milford township, Passaic county.

Ann. Reps., 1876, pp. 52–53; 1879, p. 81; 1880, p. 116.

CENTENNIAL, or SQUIER'S MINE, near State line, West Milford township, Passaic county.

Ann. Reps., 1876, pp. 53–54; 1879, p. 82; 1880, p. 116.

PEQUEST BELT.

SCHULER MINE, Oxford township, Warren county.
Ann. Reps., 1873, pp. 72–73; 1879, p. 82; 1880, p. 116.

ROSEBERRY MINE, Oxford township, Warren county.
Ann. Rep., 1873, p. 73.

BARTON MINE, Oxford township, Warren county.
Ann. Reps., 1873, p. 73; 1879, pp. 82–83.

SHOEMAKER MINE, Oxford township, Warren county.
Ann. Reps., 1873, p. 74; 1879, p. 83.

RIDDLE MINE, near Oxford, Warren county.
Ann. Reps., 1873, p. 74; 1879, p. 83; 1880, p. 116.

LITTLE MINE, near Oxford, Warren county.
Ann. Reps., 1873, pp. 74–75; 1879, p. 83.

QUEEN MINE, near Oxford, Warren county.
Ann. Reps., 1882, pp. 71–73; 1883, p. 141.

OSMUN PLACE, Oxford township, Warren county.
Ann. Rep., 1882, p. 73.

RAUB FARM, Oxford township, Warren county.
Ann. Reps., 1873, pp. 75–76; 1879, p. 83.

PEQUEST MINE, Oxford township, Warren county.
Ann. Reps , 1873, pp. 76–78; 1879, p. 83; 1880, p. 116.

HOIT FARM, Oxford township, Warren county.
Ann. Reps., 1873, pp. 79–81; 1879, p. 83.

SMITH FARM, Hope township, Warren county.
Ann. Reps., 1873, p. 81; 1882, p. 73.

DEATS PLACE, Hope township, Warren county.
Ann. Reps., 1873, pp. 81–82; 1882, p. 73.

HENDERSHOT, or HOAGLAND PLACE, Hope township, Warren county.

Ann. Reps., 1879, p. 83; 1880, p. 127.

COOK FARM, Hope township, Warren county.

Ann. Reps., 1881, p. 37; 1882, pp. 73–74.

KISHPAUGH MINE, west of Danville, Warren county.

The Crane Iron Company sold this mine during the past year to the Musconetcong Iron Company, owners of the adjoining Cook mine.

During the ownership of the Crane Iron Company 110,000 tons of ore were removed, and the bottom of the mine was all in ore when it was sold.

The Musconetcong Iron Company is now putting down a new slope, southwest of slope No. 3, which is located so as to "fall away" on the same pitch as the bed rock. This gives the Musconetcong company an entrance upon their Cook property.

Ann. Reps., 1873, pp. 82–84; 1879, pp. 83–84; 1880, p. 117; 1883, p. 142.

CORLISS FARM, Hope township, Warren county.

Ann. Rep., 1882, p. 74.

INSCHOW LOT, Hope township, Warren county.

Ann. Reps., 1873, p. 84; 1879, p. 84.

STIFF FARM, Hope township, Warren county.

Ann. Rep., 1873, pp. 84–85.

POTTER FARM, Independence township, Warren county.

Ann. Reps., 1873, p. 85; 1879, p. 84.

STINSON FARM, Independence township, Warren county.

Ann. Reps., 1879, pp. 84–85; 1881, p. 37; 1882, p. 74.

GARRISON FARM, Independence township, Warren county.

Ann. Reps., 1873, p. 85; 1881, pp. 37–38.

DAVIS MINE, Independence township, Warren county.

Ann. Reps., 1873, p. 85; 1881, p. 31; 1883, p. 143.

ALBERTSON PLACE, Independence township, Warren county.
Ann. Rep., 1873, p. 85.

SHAW'S MINE, Independence township, Warren county.
Geology of New Jersey, 1868, pp. 659–660; Ann. Rep., 1872, p. 18.

HOWELL FARM, Independence township, Warren county.
Ann. Reps., 1873, pp. 85–87; 1878, p. 101.

CARROLL PLACE, Independence township, Warren county.
Ann. Rep., 1873, p. 87.

GREEN PLACE, Independence township, Warren county.
Ann. Rep., 1882, p. 74.

CUMMINS MINE, Independence township, Warren county.
Ann. Reps., 1881, p. 38; 1883, p. 144.

AYRES PLACE, Independence township, Warren county.
Ann. Rep., 1881, p. 38.

SCHAEFFER FARM, Independence township, Warren county.
Ann. Reps., 1873, p. 87; 1880, p. 127.

MARING PLACE, Allamuchy township, Warren county.

HIBLER, or LIVESEY'S SHAFT, Allamuchy township, Warren county.
Ann. Reps., 1873, p. 87; 1879, pp. 85–86; 1880, p. 117.

WINTERMUTE'S OPENING, Allamuchy township, Warren county.
Ann. Rep., 1880, p. 127.

HAGGERTY'S DIGGINGS, Allamuchy township, Warren county.
Ann. Reps., 1873, pp. 87–88; 1876, p. 52; 1879, p. 86.

GLENDON MINE, Green township, Sussex county.
Ann. Rep., 1873, p. 88.

McKEAN, or BIRD MINE, Byram township, Sussex county.
Ann. Reps., 1874, pp. 28–29; 1879, p. 76; 1880, p. 118; 1883, p. 145.

BYERLY OPENINGS, Byram township, Sussex county.
Ann. Rep., 1879, p. 86.

ROSEVILLE MINE, Byram township, Sussex county.

Geology of New Jersey, 1868, pp. 628–631; Ann. Reps., 1873, p. 88; 1880, p. 118; 1883, p. 145.

ANDOVER MINE, Andover, Sussex county.

Geology of New Jersey, 1868, pp. 640–657; Ann. Rep., 1873, p. 88.

SULPHUR HILL MINE, Andover, Sussex county.

Ann. Reps., 1873, p. 88; 1879, pp. 86–87; 1880, p. 118; 1883, p. 145.

TAR HILL MINE, Andover township, Morris county.

Geology of New Jersey, 1868, p. 657; Ann. Reps., 1880, p. 118; 1883, p. 145.

LONGCORE'S MINE, Andover township, Sussex county.

Geology of New Jersey, 1868, pp. 657–658.

STIRLING HILL MINE, Sparta township, Sussex county.

Ann. Reps., 1877, p. 52; 1879, pp. 87–88; 1880, p. 118; 1883, p. 146.

HILL MINE, Franklin Furnace, Sussex county.

FURNACE VEIN MINE, Franklin Furnace, Sussex county.

Geology of New Jersey, 1868; pp. 658–659; Ann. Reps., 1873, p. 88; 1879, pp. 88–89; 1880, p. 118; 1883, p. 146.

GREEN'S MINE, Vernon township, Sussex county.

BIRD MINE, Vernon township, Sussex county.

Notes of Green's and Bird mines in

Geology of New Jersey, 1868, p. 660; Ann. Rep., 1879, p. 89.

ZINC ORE.

The zinc mine in Oxford township, Warren county, on the Raub place, a mile north of Oxford Furnace, is less than 100 yards west of the old shaft, which was sunk several years ago, and of which there was a notice in the annual report for 1875, p. 36. The principal openings are on the north side of the Belvidere road, and 100 feet from it. (See Sheet No. 2 of Atlas of Topographical Maps.) The ledge containing the zinciferous rock dips west, steeply, and lying against its base there is an accumulation of sand of drift origin. When visited no rock had been found on the west, the pit then being 30 feet deep. The rock of this ledge is a crystalline limestone, whose beds stand almost vertical, dipping very steeply to the north and striking nearly east and west (a few degrees north of east.) A few rods away to the north there is an outcrop of gneissic rocks. The ore-bearing portion of the rock has a more northeast course than the strike of the bedding, and is in two *veins,* which are separated by a breadth of 5 feet of white limestone. At the time of visit, there had been about 200 tons of the rock, carrying the blende, thrown out, and a few tons of selected ore put at one side. The percentage of metal in the latter was reported to be as much as 50 per cent., while the big heap was said to yield an average of 12 per cent. The blende is of the common, black, resinous variety. A steam engine on the bank serves to drive the drills, hoist the ore and rock and raise the water. No drifting had been done to test the extent of the ore, and the work was all in the shaft-striking.

On the south side of the road, and west of the mine, blende occurs in a black rock, which traverses, or is, apparently, imbedded in the white limestone. The latter is very much mixed with the micaceous and hornblendic (?) rocks. Small openings were made in the side hill, close to the road, but no workable, zinc-bearing rock or ore could be found. Carbonate of zinc (hydrozincite) occurs here as white to grayish white incrustations upon the rock faces, but the quantity of ore is inconsiderable, though the occurrence is interesting and suggestive, possibly of other ores in the same ledge, yet undiscovered.

This locality was opened about a year ago by the Messrs. Hartpence, and the property was leased by A. J. Swayze and Hartpence. A recent report states that the property is about to be tested thoroughly by a company of New York capitalists.

The occurrence of zinc ores at Franklin Furnace, at Stirling Hill, at Andover, in Sussex county, and on the Howell farm, on Jenny Jump mountain, and at this place, in Warren county, all in the Pequest belt of Archaean rocks, and the absence of zinc from the rocks elsewhere in the Archaean highlands, indicates it to be a characteristic occurrence of this belt, and the white, crystalline limestone on the northwest border of the highlands as the *country rock,* in which searches for zinc ores are to be made. It should be remarked that the zinc compounds of all the localities, excepting the mines at Franklin Furnace and Ogdensburg, are sulphides and hydrous carbonates, the franklinite and willemite not being found at any of them.

Although the searches for zinc ores have not generally been successful, they are not to be regarded as altogether unpromising or hopeless. The geological features of this whole range of crystalline limestone are such as to warrant explorations in it. The discovery of zinc ore does not, however, prove the existence of workable deposits or veins, nor justify the speculation so common at the announcement of such finds.

The mines at Franklin Furnace and at Ogdensburg are worked steadily, and the production is nearly as large as in any previous year of their history, as is shown by the statistics of ore shipments. The total amount carried on the lines of railroad from these localities in 1884 was 40,094 tons. Of this total nearly all was from the Mine Hill mines, and shipped at Franklin. Two companies are there at work, the New Jersey Zinc and Iron Company and C. W. Trotter, lessee, on the part of the *vein* owned by the Lehigh Zinc and Iron Company.

The mines on Mine Hill, according to reports received therefrom during the year, are as promising and as capable of large production as ever they were, and the permanence of this great zinc-ore bed is assured for a long time to come. It is fully equal to all that the most sanguine of its friends have ever hoped for it. And the steady mining industry, of which it is the basis, is one of the sources of prosperity to the State. Unique as it is in its minerals, it is as wonderful for its wealth.

X.

DRAINAGE.

THE GREAT MEADOWS DRAINAGE.

The work of the commissioners upon the drainage of the Great Meadows in Warren county is closed. This work having been planned by the Geological Survey, it is not inappropriate at this time to give an account of its progress and successful completion.

The Great Meadows are lands bordering on the Pequest river, and its branches, Trout brook and Bear creek, in the townships of Independence, Allamuchy and Frelinghuysen, in Warren county, and Greene, in Sussex county. The southwestern end of the meadows is at Danville, and they extend upward on the main stream to Tranquillity; up Trout brook past Allamuchy, and up Bear creek well towards Johnsonsburg. The extreme length is 8¼ miles, and the breadth varies from 1¾ to ¼ of a mile. The area covered by them was assessed at 6,038$\frac{14}{100}$ acres. A much larger area than this has been materially benefited by the drainage, and may be fairly considered as part of the meadows.

Through these meadows the stream ran in its crooked and shallow channel.* Whenever heavy rains fell, and the water was suddenly poured from the surrounding mountains down to the stream, this soon overflowed its banks, and the surplus covered the meadows quite up to the foot of the hills. Such freshets were frequent and very slow in subsiding. The whole valley, between Jenny Jump mountain on the northwest and Allamuchy mountain on the southeast, was all in swamp or wild meadow. From Danville up to Long Bridge, a distance of 5¾ miles, there was no road across it; the timber in the swamps could only be got out in winter when the frost made the

* The Pequest and its branches above Danville has a drainage area of 77 square miles. Of this, Trout brook drains 10⅔ square miles; Bear creek, 16⅔ miles; and the main stream of the Pequest, 49⅔ miles.

surface hard enough for teams to go over it; many cattle were mired and perished in the marshy ground; and some parts, such as that named goose pond, were so inaccessible, even to sportsmen, that wild geese made their nests there and reared their young.

The valley between the mountains has been, at some remote period, dammed across by an enormous bank of clay, sand, gravel and bowlders, glacial material deposited by the ice of the glacial period. The effect of this was to form a long, narrow lake, extending far up the Pequest and its branches. The outlet to this lake must have been in the line of the present bed of the Pequest, making a long course of three miles around by the village of Vienna instead of the short distance of a mile across the gravel hills from Danville to the Pequest, near Townsbury. In this channel the loose material was worn away down to such as was firm enough to resist the force of the running water. The lake thus left has gradually filled with the fine earth washed from the hills and higher country surrounding. The finest and best of the soil from the upland has accumulated in the valley, filling its whole breadth up to its present height. This accumulation of sediment ceased when its surface became so high that the current of water was rapid enough to carry it down stream instead of allowing it to settle and fill up the valley still higher. There is no doubt that this filling of the valley began when the bottom of the outlet, near Vienna, was much higher than it was in later times. There is a very large tract of country northeast of the Great Meadows which has the same fine sedimentary material for its soil, and the same freedom from gravel and bowlders, that the swamps in the meadows have, but the wearing down of the outlet left it dry and naturally prepared to make the best of farm lands.

The surface of the meadows seems to be a dead level, but examination proves it to have a descent with the Pequest of near 2 feet per mile; and across the meadows the surface slopes from the foot of the mountains towards the stream at rates varying from 2 to 4 feet per mile. The hard ground along the stream was covered with a heavy growth of such timber as thrives in wet ground. But large portions of land farthest from the streams became covered with muck and wild grass, and were entirely bare of timber. These constituted the meadows; their surface was higher than that of the swamp lands, and they were like great sponges which swelled up with the water which they held; and so great was their capacity in this respect, that three considerable streams on which saw mills were built, and which discharged their waters into the meadows, were entirely lost, no trace of the streams appearing, and all the water from them soaked through the great body of the meadow-earth into the Pequest. The Pequest itself had a very shallow channel, and a crooked course through these meadows. In dry seasons it was sufficiently large to carry all the water that came into the upper part of the valley; but in wet seasons, and much of the winter and spring months, the water overflowed its banks, and spread itself over the whole breadth of the valley like a great lake, rendering the land inaccessible and nearly worthless, besides obstructing the free passage and communication between the farms on the opposite sides of it.

This portion of the state was taken up by settlers soon after 1750. And the inconveniences attending this large tract of wet land were soon felt. Besides, the inhabitants along its borders were subject to severe visitations of malarial and other disorders arising from large surfaces of wet land and stagnant water. And early efforts were made to drain it. About 1808–10, Richard Addis and Mr. Wadsworth began a ditch to extend from the southeast border of the meadow, near Schmuck's saw mill, to the Pequest, near the head of Post's island. This was nearly a mile and three-quarters long, and was a very large undertaking for two persons. The upper end, and for nearly a mile and a half down, appears to have been well done, but the end where it should have joined the Pequest, judging from present appearances, was not properly opened. The fall in the ditch was such, however, as to drain off the water from the meadows about the upper end of it, and for a time it was considered a great success, but the check in the current, from the lack of any outlet, hindered it from clearing the channel, and the land went back to its original condition. The owners of the land were discouraged, and abandoned the attempt to drain it.

Along the northwest and west ends of the meadows, a number of attempts were made by individual farmers to drain their portions of them. Long and expensive ditches were dug from the shore across the meadows to reach the Pequest. Amos Hoagland, Sr., Thomas Fleming, David Menell, Nathan Hoagland, Joseph Coryell, Samson H. Albertson and John Stinson, all undertook such works, at various times between 1810 and 1830, and all abandoned them in the same way, because there was no outlet by which the flow of water in the drains could clear them.

Between 1830 and 1840, Dr. J. Marshall Paul made large and expensive improvements on the northwest side of the meadows, on what is now known as the Wurtz property. This was attended with marked success, for a time. He raised corn of the finest growth and yield ever known in that part of the State; a field of about 10 acres averaging over 130 bushels of shelled corn to the acre. But the lack of an outlet by which to keep the ditches clear soon caused the land to revert to its former condition. And the failure to secure the encouragement and support of other interested land owners, in a united effort to get a proper and sufficient outlet, led him to abandon the enterprise, great and useful as he considered it to be.

Smaller improvements on the same side of the meadows were also attempted by Robert Shaw, Joseph Garrison and others, but they were all abandoned for the same reason after short trials.

On the southeast side of the meadows the Cummins' made large and expensive ditches, with the view of improving their property. One of them was nearly a mile and a half long, running parallel with the border of the flowed grounds, and ending without any outlet in the meadows on the southeast and upper end of Post's island. The descent of the surface was such that much of the flood water on this part of the meadow was carried off in the ditch and overflowed on the lands at its southwest end. Like the other attempts at improvement this was successful at first, but had lost much of its efficiency by the gradual closing of the ditch before the last and thorough work of drainage was begun.

In the spring of 1870 a survey of the Pequest through the Great Meadows, and for two miles or more below, was made by Prof. Edward A. Bowser, for the Geological Survey of New Jersey. This survey was made about the middle of April. The water at that time not only filled the entire channel of the stream, but overflowed and covered its banks to the depth of 2½ feet. His passage down the stream in a boat, for the purpose of measuring the depth of the water, was both difficult and dangerous. The channel was obstructed by brush and trunks of trees lying across it, so that it was very troublesome to pass them, and in some places it was hard to tell where the main channel was. The work, however, was accomplished, and accurate levels were also taken to show the rate of descent of the stream from point to point. His report, with maps and profiles, was printed in the annual report of the State Geologist for the year 1870. His plan proposed to cut down the bed of the stream to a uniform grade throughout, and to widen it to a breadth of 30 feet, and to deepen it from 3 to 5 feet. This would require a cutting down of the hard earth at the outlet 5½ feet, would make the channel capacious enough to carry the whole of the water within its banks, and give to the current a velocity of a foot and a half a second, or about a mile an hour.

An application was made by a portion of the owners of the Great Meadows to have them drained under the direction of the managers of the Geological Survey, as prescribed by the act to promote the drainage of lands. Under this authority, Amos Hoagland, of Townsbury; James Boyd, of Vienna, and Samuel S. Clark, of Belvidere, were appointed by the Supreme Court, commissioners to execute the work. Dr. Clark declined to serve on the commission, and William L. Johnson, of Hackettstown, was appointed to fill the vacancy. They began the work in 1872, and all continued in it to its close. Abram R. Day, of Hackettstown, was employed as engineer of the work, and continued to act in that capacity until his death, which occurred September, 1880. The engineering work was completed shortly before his death.

The plan adopted was that proposed by Prof. Bowser. The course of the channel was to be followed, and no attempt made to straighten it to any noticeable extent.

The work was done mainly by a floating steam dredge. This was placed in the stream at the head of the channel to be deepened, and made to cut its way in front down stream to the proper width and depth. The water of the river would fill the space from which the earth was taken out, and allow the dredge to be floated down as fast as the channel was opened. The earth lifted out was deposited on the banks on either side. This plan of work was altogether practicable and successful. There was hard bowlder drift and clay met in the outlet near Bulgin's bridge, and also at some other points between there and the lower end of the work below Vienna. That at Bulgin's bridge had to be lowered 5½ feet. This was the deepest cut of any on the work, and the one essential to its success; for there can be no doubt that the whole of the Great Meadows was produced by the deposit of this mass of clay, sand and bowlders across the channel of the Pequest in the glacial period. And the cutting through it again lowers the bed of the stream, so that all its waters can be carried within its banks and leave the flat ground of the former swamp dry and habitable.

The material excavated in the channel, through the meadows, was a fine sediment, free from bowlders or gravel, and of such good quality for agricultural use that when fairly exposed to the weather it crumbled at once into a fine soil, and soon became covered with a luxuriant growth of grass. There was no difficulty in taking this material out, except where buried logs were met. These were quite common, and were found at all depths—as far down as the excavation went. They must have been buried for hundreds of years, but were quite sound, and had to be cut off at the banks in order to hoist them out of the way.

The dredging was begun in August 1876, and was completed in about four years.

A deep drainage ditch was cut along the southwest side of Roe's island, and extending to the Pequest, just above Bulgin's bridge, in 1876.

The old Addis and Wadsworth ditch was opened, and extended to the Pequest, in 1878.

A ditch along the southeast side of Post's island, to open the passage from Cummins' ditch down to the Pequest below the island, was cleared or opened anew in 1878.

The Stinson's mill ditch on the northwest side was also opened in 1878.

The whole length of the main channel opened is 10½ miles. The ditches mentioned are about 4 miles long.

The total descent from the mouth of Trout brook, 294 yards above Long bridge, to Vienna bridge, a distance by the stream of 6.29 miles, is 13.43 feet, which gives a descent of over 2 feet per mile. And the flow of the water in the stream is remarkably uniform in its velocity. Trials made in 1878, and also in 1884, showed a velocity of a foot and a half per second; which is about one mile an hour, and is the velocity calculated for at the outset by Prof. Bowser.

The effect of this improved drainage is seen throughout the whole length of the meadows. The lands are accessible at all seasons. The goose pond is now entirely dry, and corn has been grown upon it this year. The saw mill streams, formerly lost in the marshy ground, are now plainly marked by open channels quite to the Pequest. The water in the stream has scarcely overflowed its banks, in time of freshet, since the channel was deepened. And the whole of the meadows is now dry enough to be tilled and cropped the same as upland. Some 500 acres are already cleared and in cultivation, and most excellent crops are grown upon them. With good management it requires but a short period of cropping to pay off all the expense incurred in draining the ground.

The fine earth and the swamp muck both help to make the soil a rich and productive one; and it is very important for keeping up the continued fertility of the soil that the organic matter, which forms a thick layer on its surface, should not be burned off, but should be carefully preserved from fires, and mixed up, in plowing, with the earth which lies under it. In this way its productiveness can be kept up for an indefinite length of time.

The cost of the work has been $108,241.88. It has been made much greater than it otherwise would have been by the expensive and protracted litigation maintained by the land owners in resisting the payment of their taxes for the improvement. This has necessitated the payment of large fees to lawyers, and of heavy charges of interest for delayed payment of bills.

FINANCIAL STATEMENT.

Original contract	$70,980 49
Clearing creek	1,220 33
Interest paid to January 1st, 1879	10,171 95
Temporary loan repaid	7,147 12
Commissioners, for services	3,927 51
Superintendent, engineer, &c	3,791 89
Counsel fees, costs and expenses	5,134 98
Advertising, printing, &c	1,114 81
Right of way	615 44
Postage and incidentals	178 39
Engraving bonds, &c	371 25
Auctioneer	40 00
Agent for collection	2,219 56
Clerk, for services	140 00
Interest to May 25th, 1882	1,188 16
Total	$108,241 88

The velocity of the current, as it is now established, is as great as it can be without its cutting away the bottom and banks of the stream. And it is not likely to become clogged if attention is given to the removal of obstructions from brush thrown in by careless wood-choppers, by the falling of trees from the banks into the channel, or by the uncovering of old logs which are found buried in the earth. There should be a system of supervision put in operation with authority for keeping the stream clear of obstructions, and if this can be carried out, there is no doubt the drainage can be kept in the same excellent condition that it is now.

This supervision would also have the effect of extending, without heavy expense, the benefits of the drainage much farther up the Pequest, Trout brook and Bear creek. The lowering of the bed of the Pequest has left a fall of 3 or 4 feet where the improvement ends, and as the earth in the bottom is just ready to be moved with any increase in the volocity of the current, that in the bottom of the streams at the places mentioned has been moved and the bottom of these streams is being lowered to the same extent as that of the Pequest was by the dredge, and a new bottom is being formed with the same descent it had before the dredging was done, but 3 or 4 feet lower. Already this new bottom has been formed for 1,100 yards up the Pequest, and materially deepened for about 600 yards further; up Bear creek it has been deepened to the Pequest grade for 600 yards and lowered 600 yards further; and up Trout brook a mile or more. A little work in removing logs and stumps, as they are uncovered, would hasten this change very greatly.

The commissioners have carried out their work faithfully and persistently in the face of great and uncalled-for opposition. And they have the satisfaction of having executed a great public improvement, and of having added to Warren county a large area of the best farm lands within its bounds.

PASSAIC DRAINAGE.

The drainage work projected for the lowlands on the Passaic above Little Falls has not yet been done. The financial depression of 1873, and later, has hindered enterprises of this kind from being carried through. The need for the work is as urgent as ever. There are more than 10,000 acres of land subject to overflow by freshets in the Passaic at any season of the year, which could be saved from this disaster by lowering the obstructions at Little Falls and Two Bridges 7 feet. The other portions of the channel are already so low that very little expense would be required to bring them to a uniform grade with the lowered obstructions mentioned above.

The damages to the hay on these lowlands, from being overflowed by roily water last summer, could not have been less than $40,000 or $50,000, and the land itself is damaged to the amount of more than half its value by the uncertainty of its crops from the same cause. The water which is left stagnant on these flowed lands in summer is a fruitful source of disease to the dwellers on the adjoining uplands, and a source of great depreciation in their value.

The carrying out of this improvement would abate a serious public nuisance, and bring into profitable use one of the most beautiful valleys in the State. It is very desirable that arrangements should be made by which the drainage could be effected.

XI.

WATER-SUPPLY.

ARTESIAN WELLS.

The report for 1882 recommended the boring of artesian wells in Southern New Jersey for the purpose of securing an ample supply of pure and wholesome water. The large body of citizens who spend the summer vacation at the numerous sea-side resorts, and are seeking rest and recuperation there, demand a water of unquestionable purity. The great extent of the marl beds, and their very uniform thickness, dip and structure, led to the belief that if some of their beds were pierced it would allow the water in them to escape in flowing wells. The report of 1883 gave an account of the successful boring of wells at Ocean Grove and Asbury Park. In the strata which were pierced the same regularity was seen that had been observed at their outcrop.

The confidence inspired by the abundant flow of pure and sparkling water from these wells has led to the sinking of several other wells along the coast. The town of Red Bank is supplied with water from them. One has been bored at Ocean Beach; a second one at Asbury Park; one at Lakewood, and one at the Berkeley Arms, on Squan Beach; other wells have also been bored at Marlton, and at Mays Landing and Weymouth. In all these the same regular succession of strata is observed, and the same gentle descent or dip to the southeast.

The geological structure of all Southern New Jersey is so regular and simple, and the advantages of understanding it of so much practical importance, that it was thought best to again insert a profile section of the succession of strata which make up the southen half of the State. See page 21.

BORED WELLS.

At Red Bank a boring was made to reach the sand under the Lower Marl bed and ascertain how much water could be obtained from it. It was known to be the stratum from which the wells at Asbury Park, Ocean Grove and Ocean Beach get their supply of water. And the boring was to test the question whether the stratum would yield good water there in sufficient quantity to supply the town. The marl stratum is there about 30 feet below tide level, and the surface where the well was tried is about the same height above that level. The boring was continued through the marl, and the water was found at a depth of between 80 and 90 feet. The well, which was in earthy material, was lined with an eight-inch tube. On pumping, it was found to yield about 40,000 gallons a day. The water rises within 6 to 8 feet of the surface, but does not overflow. A second well was bored and lined with a six-inch tube. It was put down to a depth of 90 feet, but appeared to yield no water. After several ineffectual trials the tube was raised a few feet and the water rose in it the same as in the other well. The tube had been driven through the water-bearing sand into the underlying clay, and in that way the water had been shut out. This is an oversight which has frequently been the cause of failures in boring artesian wells.

The supply of water of good quality from this stratum of sand being assured, the water commissioners next examined the question as to the best method of getting the quantity needed for the wants of the town; whether by sinking a number of tubes at some distance from each other, and connecting all of them with a centrally located pump, or to dig a very large open well and pump from that. The conclusion reached is best given in the following report, communicated by William S. Sneden, Esq., one of the commissioners, and their secretary:

"OFFICE BOARD OF WATER COMMISSIONERS,
"RED BANK, N. J., December 20th, 1884.

"*Prof. Geo. H. Cook, State Geologist, &c.:*

"DEAR SIR—From the kindly interest you took in the experimental artesian well bored for our water-works last summer, I infer that our subsequent operations may also be of interest to you. As you remember, we found the water-bearing sand as you had predicted, directly under the marl stratum, at a depth of 66 to 69 feet below the surface. This gives the elevation of the sand, say 35 feet below ordinary tide.

"Our engineers, Messrs. Wilson Brothers & Co., of Philadelphia, advised the construction of an open well, 15 feet in diameter, sunk to the water-bearing sand, anticipating a larger supply of water from the increased area, and giving a larger volume in store to pump from after the pumping machinery should be at rest, as at night, in case of fires. The well has been completed, but it was thought advisable to stop sinking the main wall of the well when it reached within 10 feet of the sand, to secure a solid foundation on the marl. From that point 5 large cast-iron pipes, 36 inches in diameter, were put down through the 10 feet of marl to the water-bearing sand. A bed of concrete, 3 feet thick, made of English Portland cement, sand and broken stone, surrounds the upper or bell-end of the pipes, and extends under the curb of the main well walls, making a tight floor, allowing the water to come through the cast-iron pipes without contact with the marl. The walls of the well, 20 inches thick, laid in Portland cement mortar, were built on a shoe or curb of boiler iron and white oak, 26 inches deep, tapering to a cutting edge at the bottom. As the material was excavated and hoisted out, and the walls sunk, additional brick work was added, until the depth of 56 feet was reached. A pulsometer, capable of discharging 500 gallons per minute, supplied with steam from a 25 horse-power boiler, kept the water down. Marl was found at 29 feet, at 40 feet, and on to 48 feet large lumps of hard marl and rock were encountered; and from 48 to 52 feet the excavation was through a hard, seamy marl, closely compacted with shells, specimens of which I send you.

"At a depth of 42 feet, after the lumpy stratum was struck, a large spring burst in, flowing at the rate of 100 gallons per minute, and, at the same time, the water in the artesian wells (100 feet off) lowered some 25 feet. This spring kept with us through the shelly marl, and worked its way down under the curb after the dry, ordinary marl had been reached. After we had sunk the cast-iron pipes in the bottom, and the water began to flow through them, the spring gradually lessened.

"It is evident that this water must have worked up through some "pocket" of the seamy marl which must have extended down through the otherwise impervious marl to the sand, and, running through this pocket, squeezed its way horizontally to the opening we had made. While we were pumping 100 to 125 gallons per minute out of the well at 50 feet below the surface, and the water in the artesian pipes standing at, say 45 feet, or but 5 feet higher, the surface-water stood at its normal height, in the vicinity, which was from 6 to 8 feet below the surface.

"The water now comes in our completed well at the rate of about 250,000 gallons per day, rising to a point within 12 feet of the surface of the ground.

"The pumps are to be vertical, the steam end at the top of the well, with the water cylinders 30 feet below, so that, with 20 feet suction, the maximum flow can be availed of.

"We constructed a reservoir on the hill, just east of the town, at an altitude of 145 feet above tide, with a capacity of 900,000 gallons. Our whole works, when complete, with 3 miles of mains now laid, will cost about $45,000.

"Respectfully yours,

"WM. S. SNEDEN."

The water from the well is clear and free from any organic matter. Its reaction is slightly alkaline. Three different samples of the water gave, in solid matter per gallon, 6.8 grains, 6.9 grains, and 5.6 grains. It contains a mere trace of iron, and the solid matter is mostly carbonate and sulphate of lime. The water is soft and fit for all household purposes, and for making steam. Its purity is unquestioned.

The well at ASBURY PARK, bored by Mr. Uriah White, continues to yield an abundant supply of water—considerably more than it did when it was first bored. A late trial of its yield, by a fire engine, showed it to be capable of supplying 95,000 gallons of water in 24 hours.

A second well has lately been bored there by Mr. White. The pipe in it is down 393 feet, and the drill has been sunk to 448 feet. He thinks the principal flow of water was from that depth. The beds of marl were met much the same as in the well bored last year. The flow of water, as far as tested, is about 20 gallons a minute. Its temperature is 60° Fahrenheit.

The artesian well at OCEAN BEACH, Monmouth county, is on the property of Mr. Eben. C. Jayne, at the corner of Ocean and Sixth avenues. The well is about 400 feet from the ocean, has a total depth of 485 feet, its wrought-iron casing pipe 471 feet, and a diameter of 3 inches. It was put down in the spring of 1884, by the Southwark Foundry and Machine Company, of Philadelphia, two months time being occupied in the work, and the cost a little over $1,100.

Soon after completion, the flow of water at the surface level, and by actual measurement, was 25 gallons a minute, or 36,000 gallons a day. The pressure was sufficient to cause it to rise vertically 34 feet above the ground, and about 50 feet above low-water mark of the ocean. No measurement of the daily yield has since been made, but it was immediately connected with the supply pipes of three large cottages, and has continuously afforded not only an ample supply for them, but also a surplus equal to the supply of many more, should it be required.

In quality the water is clear, colorless, pleasant to the taste, perfectly wholesome and suitable for drinking, culinary and household purposes, although a little hard and containing a trace of iron. Coming from such a great depth, from under a series of clay beds, and, from such a distance inland, it is entirely free from any and all surface contaminations, a great desideratum sanitarily.

The well was bored through the same succession and series of sand, clay and marl strata as the wells at Ocean Grove and Asbury Park, and the water is found in a sandy layer under the Lower Marl bed.

At LAKEWOOD an artesian well has been bored for the purpose of getting a supply of unquestionably pure water for the Laurel hotel. It has been sunk through the Middle and Lower Marl beds, and the water-bearing stratum of sand has been found at the depth of 475 feet from the surface. The well is upon ground 50 feet above tide level, and the water rises in a tube about 17 feet above the surface. It was hardly to be expected that the water would rise to the level of the ground here, and the quantity which flows is 3½ gallons per minute; by pumping, 12 gallons per minute have been obtained. The water is clear and sparkling, and the analysis shows it to be of good quality and entirely free from any suspicion of contamination by organic or other surface impurities.

ANALYSIS OF LAKEWOOD WELL.

Sodium chloride, grains to 1 gallon	0.478
" carbonate, " " "	0.968
Potassium " " " "	0.624
" sulphate, " " "	0.898
Calcium bi-carbonate, grains to 1 gallon	3.446
Magnesium " " " "	0.915
Silica, grains to 1 gallon	1.499
Sesqui-oxides of iron and alumina, grains to 1 gallon	0.046
Total fixed and volatile matter	8.874

Hardness equivalent to—

Calcium carbonate, grains to 1 gallon	3.52
Total fixed matter, at low red heat, grains to 1 gallon	6.502

At Marlton, another artesian well has been successfully bored for Charles B. Chew, Esq., by Mr. Goldsmith Wilmot, of Haddonfield, who furnishes the information in regard to it. The well is 86 feet deep, and with a bore of 5⅝ inches, and has been sunk through the Middle Marl bed and down into a sandy layer, in which the well ends. Unfortunately the notes in relation to the successive layers of material passed through are lost. In general, however, they may be described as follows:

Loam and gravel, to the marl	20	feet.
Black marl	6	"
Greensand marl	15–20	"
Chocolate marl	6	"
Thin stony crust, 2 inches.		
Chocolate marl	6–7	"
Thin stony crust.		
Hard black sand, which gradually grew lighter until it became white.		
About 2 or 3 feet from the bottom, struck a very hard rock, or boulder, and drove the casing through it.		
Total depth	86	feet.

The water rose to within 24 feet of the surface. The well was then tested with a pump, driven by a steam engine, and the water was not lowered an inch, after running the pump steadily for 8 hours. The quality of the water is good; its temperature is 53½ degrees.

At the farm of Benjamin Cooper, two miles east of Marlton, in Burlington county, an artesian well has been sunk which supplies a large quantity of unexceptionably good water. It is located over the Middle Marl bed, and the materials passed through, as reported by Mr. Cooper, are:

Upper soil	28	feet.
Ironstone (sand and oxide of iron)	3	"
Greensand marl	1	foot.
Ironstone	1	"
Greensand marl, black and chocolate marl, no accurate account of each kept	19	feet.
Clean black sand, with white specks	14	"
Stopped in open, coarse sand with belemnites	4	"
Whole depth	70	feet.

The well was tubed with a six-inch pipe, and the water rose in it to within 5 feet 7 inches of the surface, and remained at that point until the water was pumped freely, after which it rose to 3 feet 10 inches from the surface. The water is clear, soft, and of excellent quality for all household purposes. Its temperature is 54°. Mr. Cooper has erected over the well a 12-foot iron turbine wind-mill. After running the pump for 3 days, with a good wind during the day, at no time was the water lowered more than 3 inches, though the pump was showing a steady inch stream.

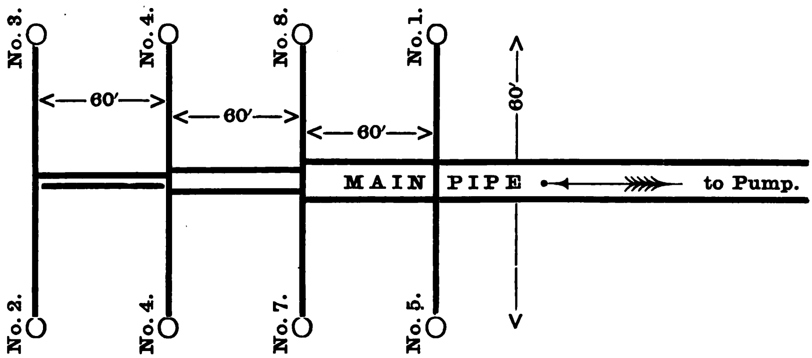
BERKELEY ARMS Artesian Well. This well is located on the beach, opposite the mouth of Toms river, and was bored to get a supply of pure water for the house. It was sunk down through various strata of sand and clay, and at about 450 feet a stratum of greensand was met. After passing through this, water was found at the depth of 475 feet. This greensand is probably the *upper layer of the Upper Marl bed*, as the Lower Marl bed, with its usual dip, would not be met at a depth much less than 900 feet, while the upper layer of the Upper Marl bed, with its more gentle dip, would be met at about the depth at which it was met in sinking this well. It is a matter of much interest to know that there is a stratum of water-bearing sand under the Upper Marl bed, as it is met with under the beaches, and can be reached at much less depth than the Lower Marl bed, under which is the water-bearing stratum of sand from which the wells at Red Bank, Asbury Park, Ocean Grove, Ocean Beach and Lakewood get their supply.

The water in the well at Berkeley rises to the surface but does not flow. When pumped, it is said to have yielded 60 gallons per minute without lowering more than 10 or 12 feet.

WELLS AT PLEASANT MILLS, ATLANTIC COUNTY.

The following report of wells at Pleasant Mills, Atlantic county, has been furnished by W. E. Farrell, Esq.

"In 1873 we sunk a 3-inch well for pure water. After going through about 40 feet of yellow and white sand and pebbles, we came upon a bed or stratum of tough, hard, dry blue and blue-black clay. This blue clay was about 8 feet thick. As soon as this stratum of clay was passed the water burst through and rose in the pipe to the height of 13 feet above the level of the ground. The water was very black at first, being mixed with fine black sand and *smooth* pieces of blue clay, which came up with the water in flat, round, smooth pieces, from ½ to 3 inches in diameter, and from ¼ to ½ inch thick. In about three days the well cleared, and, having thrown out about sand enough to to form an excavation at the bottom of the pipe of about 10x10x6 feet, the sand ceased to rise. The volume was found to be 124 gallons a minute, on a *level* with the ground. When the pipe was raised the *natural* flow was diminished until, at 13 feet 4 inches above the level of the ground, the water stopped rising in the pipes and stood still, neither falling nor rising. In 1880 we determined to sink another well (3-inch) about 200 feet from the first (sunk in 1873). The level of the ground was, say, two feet lower than well No. 1. At about the same distance down we struck the same water, going through the same stratum. This seemed to give the same quality of water, which is very clear, brilliant, sparkling, and 55° of temperature. We then put down six other wells, 60 feet apart. The water in all is the same, and reached through the same stratum, and we could tell within a foot when we would strike water. The inside of the pipe, when in the clay, was very dry, until within one inch of the under side of the blue clay stratum. As soon as this was penetrated the water would rush up and boil over the top of the pipe with a force due to its 13-feet head. We have 8 wells, 60 feet apart, thus:



"The well No. 1, we supposed, gave 124 gallons a minute. No. 2 the same (we supposed, as it was not measured). We sunk the other six, and the yield from all (8) is now about 300 gallons a minute. We notice that all the wells (before being piped and so closed in) were quite sensitive to each other; that is, if No. 1 was closed, No. 2 would show an increased flow. When two or more would be closed with a plug driven in the top of the pipe, those remaining open would show increased flow of water. And if *any* one of the seven were opened the others would show a *diminished* flow, which clearly proved the entire 8 wells were in the same water stratum. The water is very pure, as per accompanying chemical analysis, which shows 28.41 grains to the gallon of solid matter. Two analyses of the water were made, one in 1873, and one in 1876; they were both alike. The water, on being exposed to the air, the oxygen of the air attacks the iron in the water, and oxide of iron is thrown down as an iron rust.

"It works well in steam boilers, leaving no incrustation or scale, and no acids to eat or corrode the inside of the boilers, which the surface-water did. The surface-water from the pine and cedar swamps was so destructive to our boilers that in ten years a new boiler was entirely ruined and rendered unsafe through corrosion. The *surface* water attacking the boiler plates at the rivet holes and seams, and eating large holes or pits in the iron plates, which have the effect of "honeycomb."

"The question is, will *more* wells give more water, or have these wells tapped the *whole* stream.

"We notice another peculiar feature. We pump this water into a 60,000-gallon tank with a *rotary* fan-pump, which runs at 200 revolutions a minute. This throws the water 25 feet *above* the ground, but when the pump is *stopped*, as on a Sunday, the tank then being full, the water will run *back* through the pump and into the wells until the water in the tank is down to the *natural head* of the wells, showing that while deep wells will *yield* water, the water-bearing stratum will also take *more water* if the head is higher than the natural head, and water is so given to this water-bearing stratum, as in this case. Any other information that you may wish I shall be glad to give you."

Since the above report was written, we learn from Mr. Farrell that another well has been sunk, making nine in all, and that they propose to sink six more in the course of this year. A settling-pond of three acres is also being constructed, in which to allow the iron to settle to the bottom of the pond, so that clear water may be drawn off from the surface for bleaching paper stock.

The nine wells seem to have the same head of 14 feet 6 inches above tidewater.

He says: "We found a pine tree 38 feet below the surface, fresh and sound, and chips cut from it by the tools were the same as if cut from a growing tree; also shells and sound and green pine cones at 36 feet in another well."

At MAYS LANDING Water Power Company's works, in Atlantic county, two artesian wells have been sunk, and they are furnishing a moderate supply of pure water through a 2½-inch tube. They are in ground which is about 8 feet above high-water. From Mr. Charles Mason, superintendent of the works, it is learned that the first well was sunk for

15 or 20	feet, through coarse gravel.
40	feet, through quick-sand.
30	feet, through beach sand and layers of clay, perhaps 1 foot thick.
5 or 6	feet, fine black or blue tough clay without water. First water found under this.
40	feet of glass sand and no clay.
10	feet in sand; no increase of water.
150	feet, total depth.

The tube was driven by a sledge for 15 or 20 feet, then by steam 60 feet further, and the remainder was washed out by water under pressure. With the conveniences there, the extra cost of putting down the well was not more than $90.

It yielded about 12 gallons a minute for a week, and then gradually fell to 7 gallons a minute, at which it still continues.

The second well was stopped at 130 feet on account of meeting logs. It passed through the same kind of material as the other, and yields 3 or 4 gallons a minute. The temperature of the water is 57°.

These wells are on the bank of Great Egg Harbor river, a stream which has an abundant flow of soft water, and which, though a little brown in color, would seem to be pure enough for all purposes, but it corrodes steam boilers rapidly. The following is an analysis of the water from the river:

ANALYSIS OF GREAT EGG HARBOR RIVER WATER.

A gallon of the water, which is 58,372 grains, on being evaporated down to dryness, at a temperature of 110°, left of solid matter	1.89	grains.
It contains of sesqui-oxide of iron, per gallon	0.17	"
It contains of sulphuric acid, per gallon	0.15	"

The water contains much organic matter. A part, at least, of the iron is present in the ferrous state, and it is this salt which gives the corrosive property to the water when used in a steam boiler.

ANALYSIS OF THE ARTESIAN WELL WATER AT MAYS LANDING.

A gallon of this water, on being evaporated at a temperature of 110°, left of solid matter, 7.69 grains.
Of sesqui-oxide of iron—only a trace.
Of sulphuric acid—none.

The water is slightly alkaline, and does not produce any ill effect in steam boilers. And the flow still continues at the same rate as was noted last June.

At WEYMOUTH, IN ATLANTC COUNTY, five and a half miles northwest of Mays Landing, and on Great Egg Harbor river, the same corroding effect of the river water on boilers is suffered. Boilers in which this water was used needed repairs every six months. Two artesian wells have been sunk there to procure water which would not injure the iron boilers. The first well was bored under the new paper mill, in 1877, and is altogether successful.

In this well a 4-inch pipe was sunk. It is 42 feet deep. It flows over at the surface of the ground, and yields 70 gallons per minute.

The second well has been bored since at the old mill, and on lower ground. A 5-inch pipe was used. It was first sunk to the depth of 47 feet, but was drawn back to 38 feet. It has a uniform flow of 52 gallons per minute. The water is taken at the surface of the ground, but a trial was made by connecting the pipe with a 2-inch pipe, when the water rose to a height of 8 or 10 feet above the surface.

The materials passed through in boring the second well—

2½	feet of old cinders.
3	feet of yellow sand.
2½	feet of coarse quick-sand.
½	foot of stony crust.
6–8	feet of coarse sand and a little gravel.
1½–2	feet of clay.
12	feet of sand.
5–6	feet of clay.
9	feet of sand.
	clay.

The water-bearing stratum of sand is probably the same with that met at Mays Landing, and the difference in depth of the wells at the two places is due to the stratum dipping towards the southeast. We have not the elevation of the ground above tide-water at Weymouth, but if it is assumed to be 25 feet, it would leave the stratum only about 15 feet below tide-level, while at Mays Landing it is 120 feet, and the stratum should descend 105 feet in the six and a half miles between the two places. This is 16 feet per mile, and is very nearly correct.

THE ORANGE WATER COMPANY, organized to furnish water to East Orange and Bloomfield, draws its supply of water from near the great Boiling spring, which marks the junction of Newark city with the townships of East Orange and Bloomfield. This spring has long been noted for its abundant and equable flow of water at all seasons. J. M. Randall, Esq., vice-president of the Orange Water Company, informs us that three measurements of the flow of water from the Boiling spring, made at different times within the last three years, have shown it to yield from 270,000 to 300,000 gallons a day. On the northwest side of this spring is the broad and shallow valley of 150 acres or more, in which the works are situated. This valley or swale has always been too wet to invite clearing, and it is still in forest. Its surface is quite even, and there are no gravel hills within it. The upper layer of earth in this area is black, and made up of muck for from 1 to 5 feet down. Underneath this is a layer of sandy clay from 6 to 17 feet thick; quite uniform in composition, though it has a few scattering bowlders in it, and it is quite impenetrable to water. This material lies directly on the red sandstone rock of the country.

Wherever this layer of sandy clay is dug or bored through down to the rock, a flowing stream of water rises, and in a tube it will rise from 2 to 4 feet above the natural surface of the ground.

The first wells, Nos. 1, 2 and 3, were bored wells.

No. 1 has a 6-inch bore, and is 86 feet deep, 78 feet of which is in sandstone rock. Well No. 2 has a 6-inch bore, and is 90 feet deep, 81 feet of which is in sandstone rock. Well No. 3 has a 6-inch bore, and is 102 feet deep; 91 feet in sandstone rock.

Each of the above wells will yield 250,000 gallons of water in 24 hours, and not draw the water down more than 25 feet below the surface of the ground.

They are situated almost in a line, No. 2 being 170 feet from No. 1, and No. 3 240 feet from No. 2.

Wells Nos. 1 and 2 are a little affected by each other in the amount of water they yield, but not enough to interfere with the above-given estimated daily yield. No. 3 does not appear to be at all affected by pumping from the others.

Well No. 4 was next sunk near a large spring. It was sunk 12 feet into the solid rock, and then lined with a heavy stone and brick wall, cemented and carried up to a height of 5 or 6 feet above the surface. It is 25 feet in its inside diameter, roofed over and filled with clear and pure water.

The water rises from the joints in the rock. These joints are nearly vertical, and traverse the rock at intervals of from 1½ feet to 3 feet. It required powerful pumping apparatus to keep the well clear while it was being sunk, and when done and the pump stopped working, the water rose very fast.

The	1st	foot	filled in	7	minutes.
"	2d	"	"	9	"
"	3d	"	"	11	"
"	4th	"	"	12	"
"	5th	"	"	14	"
"	6th	"	"	15	"
"	7th	"	"	17	"
"	8th	"	"	18	"
"	9th	"	"	21	"
"	10th	"	"	25	"
"	11th	"	"	29	"
"	12th	"	"	36	"
"	13th	"	"	49	"
"	14th	"	"	72	"
"	15th	"	"	115	"

A foot of this well holds 3,682 gallons of water, and if the pump were driven fast enough to keep the water down to 2½ feet in depth, it would supply more than 500,000 gallons a day.

Well No. 5 is located where there was formerly a spring, about 500 feet away from No. 4, and is 50 feet inside diameter, and is dug about 14 feet below the natural surface; 6 feet of this depth is in rock, and the remainder in earth. The water rises about 3 feet above the surface. In digging the well, when near the bottom, the contractor had to pump 1,250,000 gallons of water per day, to keep the work clear. And when the pump was stopped and the water allowed to accumulate,

The	1st	foot	filled in	18	minutes.
"	2d	"	"	26	"
"	3d	"	"	30	"
"	4th	"	"	46	"
"	5th	"	"	55	"

A foot in depth of this well holds 14,728 gallons, and if, by pumping, the water was kept down to a depth of 2½ feet, the well would supply daily more than 750,000 gallons. It has been drawn from since June, 1884, for the supply of the two towns of Bloomfield and East Orange, to the amount of from 150,000 to 300,000 gallons daily, without lowering the well so as to stop its overflow. While sinking this well the whole supply, amounting to about 200,000 gallons daily, was drawn from well No. 4. The latter well was slightly affected in its level, perhaps to the amount of 2 feet, while the other was being dug and walled up. The work of completing the walls and getting them thoroughly cemented and solid, required that the water should be kept out for the whole of that time, which was 40 days. In all that time the water in well No. 4 was at least 11 feet above that in well No. 5.

The flow of water from the rock in this locality is most remarkable, and is unexampled in our red sandstone regions. The quality of the water, both in the deep and shallow wells, is given in the following analyses:

ANALYSIS OF WATER FROM WELL NO. 1.

Total solids, grains per gallon		12.8000
Chlorine, as chlorides, grains per gallon	2.2422	
Sulphuric acid, as sulphates, grains per gallon,	0.3666	
Silica, grains per gallon	0.9098	
Iron and alumina, grains per gallon	0.0233	
Lime, grains per gallon	2.1461	
Magnesia, grains per gallon	0.3965	
Free ammonia	....	
Albuminoid ammonia	....	
		6.0845
Alkalis and undermined matter		5.7155

*Hardness, grains per gallon, as calcium carbonate, 4.99.

ANALYSIS OF WATER FROM WELL NO. 2.

Total solids, grains per gallon		12.1184
Chlorine, as chlorides, grains per gallon	1.1955	
Sulphuric acid, as sulphates, grains per gallon,	0.3091	
Silica, grains per gallon	0.5948	
Iron and alumina, grains per gallon	0.0233	
Lime, grains per gallon	3.7907	
Magnesia, grains per gallon	0.6531	
Free ammonia	....	
Albuminoid ammonia	....	
		6.5765
Alkalis and undermined matter		5.5419

*Hardness, as calcium carbonate, 4.5779.

* Water containing only from 6 to 9 grains of calcium carbonate per gallon, is *soft water*.

ANALYSIS OF WATER FROM WELL NO. 5.

Total solids, grains per gallon		9.838
Chlorine, as chlorides, grains per gallon	0.857	
Sulphuric acid, as sulphates, grains per gallon	0.379	
Silica, grains per gallon	1.230	
Iron and alumina, grains per gallon	0.046	
Lime, grains per gallon	2.209	
Magnesia, grains per gallon	0.712	
Soda, grains per gallon	1.936	
Potash, grains per gallon	0.227	
		7.596
Volatile matter, grains per gallon		2.242

Hardness, equivalent to calcium carbonate, grains per gallon, 5.091.

The works have cost about $200,000, and the water is raised and distributed by the Holly system of engines and pumps. There are 32 miles of pipe laid, and numerous fire hydrants set in both towns.

An artesian well was bored at the works of Messrs. LISTER BROTHERS, in Newark, in 1879. It was sunk 110 feet in earth and 505 feet in red sandstone rock—was 8 inches in diameter, and the water rose in it to within 2 feet of the surface. The water is drawn from it by a pump and steam engine, and the daily yield is 800,000 gallons. The water is clear and cold, its temperature being 55.5°. The workmen drink it and consider it very good. It is too highly charged with mineral matter to be used for generating steam. It is used for cooling and washing.

An analysis of the water in 1879 was as follows:

Sulphate of soda, in grains, per gallon	15.94
Sulphate of magnesia	25.87
Sulphate of lime	106.98
Carbonate of magnesia	1.55
Chloride of sodium	2.47
Total solid matter	152.81

About six weeks after the pumping began a second analysis was made to see if there was any diminution in the solid matter after so heavy a flow of water from the well. It was found to contain 145 grains of solid matter per gallon.

The water was again analyzed at the end of 1882, after three years of steady flow of the water, when it was found to yield 151.79 grains of solid matter to the gallon.

Another analysis was made in August, 1884, and the quantity of solid matter contained in a gallon of the water was found to be 148.83 grains.

The results of these examinations of the water, after it has been drawn in such large quantities from the well for five years, show that it has not changed in quality.

Artesian well at LOEZER FARM, a half mile east of Somerville, Somerset county, on Central Railroad of New Jersey. W. W. Merriam, Esq., proprietor, has furnished the following account of it:

The well is located on land about — feet above the Raritan river, and — feet above tide level. The work was done by Mr. Charles Spittlehouse, of Elizabeth. The bore was 6 inches in diameter, and the well 149 feet deep. The red sandstone rock comes within 18 inches or two feet of the surface; an iron pipe, 20 feet long, was driven into the bore and fitted so closely that no trouble was experienced from surface-water.

In boring, the water was struck at 13 feet, and a limited supply was found. This water rose to within 6 feet of the surface. It continued at this height till a depth of 65 feet was reached, when it fell to 32 feet, and there remained. At 75 feet something like iron ore was struck, and not a foot was made per day. The red shale rock was found all the way down to the bottom at 149 feet.

Upon testing the yield of water, it was found easy to lower it to 75 feet, below which it never fell, though always supplying the pump to its fullest capacity. The working cylinder of the pump is placed 100 feet down. This cylinder is of heavy brass, 3 inches in diameter, inside measure, with a 16-inch stroke, and has solid ball valves.

The first test of the well was 4 continuous hours, then a rest of 1 hour, and then another 4 hours' continuous work, without any signs of diminution in the supply of good water. One hundred barrels of water have been pumped from it in from 2½ to 3 hours. The quality of the water is excellent, and gives entire satisfaction for all household purposes, and for watering stock.

An examination of the water by Profs. Austen and Wilber showed it to contain 23.9 grains of solid matter to the gallon, mostly salts of lime and magnesia. It is free from organic matter, and, though scarcely to be called a soft water, it is safe and wholesome.

THE BURTON BREWING COMPANY, of Paterson, bored an artesian well at their brewery, in 1882. It was sunk in the red sandstone to the depth of 204 feet and lined with a 4-inch pipe. They use about 800 barrels of water daily, and there is always an ample supply, without any noticeable lowering of the water in the tube.

The well was bored to secure a satisfactory supply of water for the brewery, and Messrs. Katz Brothers, the present owners, say that "the beer is much superior, in taste and appearance, to that which was formerly made by the use of the city water."

An analysis of the water was made by Prof. Austen, which is here given:

Chloride of sodium, grains per gallon	2.33
Sulphate of potash, grains per gallon	0.29
Sulphate of lime, grains per gallon	1.11
Chlorate of calcium, grains per gallon	0.47
Carbonate of lime, grains per gallon	4.66
Carbonate of magnesia, grains per gallon	1.17
Alumina, grains per gallon	0.58
Oxide of iron—trace.	
Silicia, grains per gallon	0.93
Free carbonic acid—not estimated.	
Organic matter—none.	
Total grains per gallon	11.54

THE ORANGE WATER WORKS are constructed to supply the city of Orange with water. The supply is drawn from the west branch of Rahway river, in West Orange, and about 2 miles from the nearest part of the city. The stream flows through the narrow valley between the First and Second of the Watchung mountains, and is supplied almost entirely by the rain and snow-water which falls upon the mountain sides. There are no swamps and but very few springs in the valley above the point from whence the water is taken. The area of the ground which sheds its rain-fall into the stream above the dam is about 5 square miles. From the steep mountain sides the rain-water runs off very quickly and almost entirely, so that the stream, which is quite a torrent immediately after a heavy rain, soon falls to a very moderate one, and in dry weather it is scarcely large enough to be called a brook. The location, however, affords superior advantages for a storage reservoir of large size and at an elevation which admits of supplying Orange with water by gravity.

The reservoir is made by building a dam across the valley, about 2,000 feet northeast of the South Orange avenue. The dam is 30 feet high, and the water in it, when the reservoir is full, floods the valley back to Northfield avenue. The surface covered by the reservoir is 60 acres. It has an average depth of 13 feet, and the capacity of it is estimated at 300,000,000 gallons. This is enough to supply every inhabitant of Orange with 60 gallons of water a day for more than a year, and of course is ample for the supply of a population much larger than that of Orange.

This will be apparent when the amount of water that falls annually is considered, and the peculiar form and condition of the surface which favors the rapid passage of the rain-fall into the stream and reservoir. The smallest rain-fall that has been known in the vicinity of Orange, in any year for the last 38 years, was 34 inches in depth, and this was an unusually dry year. It only takes about 3½ inches of rain to fill the reservoir, and in this valley it is probable that more than half the rain-fall runs off in the stream, which, if stored, would supply a population of 50,000 or more.

The surface of the reservoir is about 330 feet above tide-water, while most of Orange is only from 150 to 250 feet above the same level. The water is carried in an iron pipe from the dam around the end of the First mountain at Milburn, and thence along the lower southeastern slope of the mountain to Orange. The supply-pipe is 6 miles long and 27 miles of pipe are laid for distributing the water to houses. There are now 485 consumers. There are 184 fire hydrants, which are sufficiently near to the most remote building to enable it to be covered by the use of 300 feet of hose, and, being supplied by gravity, are always ready for immediate and effective use.

The water supplied by the Orange water-works is almost pure rain-water. In the reservoir, which is new, or possibly from the surfaces over which it has run, it has acquired a little organic matter, but so little as to be harmless and inappreciable in ordinary uses. It is altogether satisfactory to those who use it.

The following analysis of a sample of the water, taken in December, will give some idea of its softness and purity:

ANALYSIS OF WATER TAKEN FROM A HYDRANT IN MAIN STREET, ORANGE.

Total solids, grains per gallon		4.082
Chlorine, as chlorides, grains per gallon	0.350	
Sulphuric acid, as sulphates, grains per gallon	0.210	
Silica, grains per gallon	1.166	
Iron and aluminas (sesqui-oxides), grs. per gallon,	0.741	
Lime, grains per gallon	0.076	
Magnesia, grains per gallon	......	
Soda, grains per gallon	0.379	
Potash, grains per gallon	0.274	
		3.196
Volatile matter, grains per gallon		0.886

Free ammonia, parts per million, trace.
Albuminoid ammonia, parts per million, 0.17.

Sample taken from the middle of the reservoir, December 30th, 1884, yielded of total solids, at 100 deg. Cent., only 2.356 grains to one gallon of water.

STATE WATER-SUPPLY COMMISSION.

The subject of State water-supply was, by the Legislature of 1883, committed to a board of commissioners, with authority to investigate the matter and report. These commissioners were Andrew Clerk, of Jersey City; Henry L. Butler, of Paterson; George D. Randell, of Newark; John G. Stevens, of Trenton, and Lebbeus B. Ward, of Jersey City. Much care and labor was spent by them in examining the portions of the State where the most urgent need exists for a supply of pure and wholesome water. In March, 1884, the commissioners presented an able and comprehensive report upon the supply of water to be obtained from the Passaic river basin, above Little Falls, and its quality and admirable adaptation to furnish an abundant supply for the present and future needs of Jersey City, Newark, and other towns and villages in the thickly settled country adjacent. This report was accompanied by another report from Mr. L. B. Ward, engineer of the commission, giving a detailed description of the plans devised for collecting and storing the waters in the wooded and mountainous portions of that basin, and of the engineering plans and estimates for bringing the water to the cities and towns referred to. No action was taken by the Legislature of 1884 in regard to the reports of the commission.

This is greatly to be regretted, as the need for such a supply is apparent to all, and the dangers to be apprehended from delay are very serious. The report is a good and reliable one; and the plan proposed is one by which a full supply of unquestionably pure water can be obtained, for all time, at very little, if any, increase in cost to consumers beyond the prices now paid.

The mountainous part of the State from which the water is to be collected is mostly in forest, and has very few inhabitants. The surface is stony, and the rocks are all granitic or gneissic, rocks from which the purest of water is always obtained. The land is worth more for the growth of forests than for any other purpose, and the expense of clearing and tilling it is so great that the present tendency is to diminish the small extent of such land under tillage; and the continued increase of labor-saving machinery in agriculture is drawing men more towards fields which are free from hills, stones and broken ground. The total area, from which the plan proposes to collect the water, is 465 square miles, of which two-thirds is now in forest. All of it is 200 feet above tide-water; most of it is over 1,000 feet; and the highest ground, which is on Wawayanda mountain, is 1,496 feet above tide.

Newark, Jersey City, and the country round them, covering 200 square miles, have a population of 430,000, which is $\frac{1}{3}$ that of the State. They have immense capital invested in manufacturing and other industrial enterprises, and the district is traversed by railroads, and bounded by waters on which are carried the majority of the products of the continent. In possession of all these advantages, and with still greater ones in prospect, it becomes them to sustain their reputation by a careful attention to sanitary improvements, and diminishing the percentage of deaths. The more thickly settled any country becomes, the more impure its well-waters are, and the greater the need for seeking supplies outside their limits. Most cities have to go long distances to get a supply of water, which may be of questionable purity, and lying at low levels. In our case the distance is only 16 miles to a reservoir of unquestionably pure and clean water, drawn from the mountains around, and having an elevation of 370 feet above tide-water; a height sufficient to send the water to the tops of all the houses in the district to be supplied without any labor or expense of pumping, and in quantity sufficient for a population of 2,000,000 and more.

It is a cause for regret that this source of supply was not secured years ago, when it could have been bought for a small part of what it is now worth. It is certain that it must finally be resorted to. Our neighbors in New York see the greater excellence and advantages of the supply from this source, and have only been deterred from improving it because it belongs to New Jersey.

The threatened approach of a pestilential disease should arouse attention to every preventive measure that is possible. Water rendered filthy by the drains and sewage and soakage from cities and towns is one of the most active agents in spreading this dreaded disease, and public authorities will be held responsible by sufferers from its use. And a properly devised and managed system of finance could carry this great and lasting improvement through to completion, without sensibly increasing the burdens of taxation.

The report of the Water Commission comes from engineers of the very highest standing, and is full and accurate on all its points, and can be safely relied upon in its statements, plans and estimates.

REPORT ON THE PURIFICATION OF DRINKING-WATER BY ALUM.

BY PROFS. PETER T. AUSTEN, PH.D., F.C.S., AND FRANCIS A. WILBER, M S.

New Brunswick, N. J., February 14th, 1885.

To Prof. George H. Cook, State Geologist of New Jersey:

Dear Sir—In accordance with your request, we submit the following report on the purification of water by alum.

Respectfully yours,

Peter T. Austen,
Francis A. Wilber.

The many discoveries that have been made during the last years in regard to the transmission of diseases by drinking-waters have caused attention to be directed to the methods of its examination and the processes for purifying it. Chemical analysis can establish the presence of albuminoid matter in water, and by its means we are able to state if the water under examination can become a suitable nidus, or medium, for the development of disease germs. If the germs are actually there, or if the water contains a virus, or ptomäine,* biological examination alone can determine.

* Putrefaction alkaloid.

While physicians and scientific men are experimenting on the methods of water examination, and are endeavoring to understand fully the meaning of the results obtained, the public are chiefly interested to have some method by which they can purify their drinking-water in a simple, cheap, efficacious and expeditious manner.

Running over the substances which have been suggested and tried for the purification of water, there is none that seems to offer the advantages of alum. Particular attention was directed to its use by Jennet in 1865, in an article published in the *Moniteur Scientifique* (page 1007). He found that 0.4 grams of alum to a liter of water (23.3 grains to one gallon), rendered it drinkable, even when it was quite full of foreign matter. The time taken for this clarification was from seven to seventeen minutes.

Alum is a double sulphate of potash and aluminium, and in this case breaks into potassium sulphate, which remains in solution, and a basic aluminic sulphate. This basic sulphate of aluminium, the composition of which is undetermined, precipitates as a more or less gelatinous and flocculent mass, and carries down with it the foreign matters and humus bodies. The sulphuric acid set free in the formation of the basic aluminic sulphate attacks the earthy and alkaline carbonates, which are always present, and forms with them sulphates, setting carbonic acid free. Aluminic sulphate acts like alum. Aluminic acetate and ferric acetate do not give such good results. Peligot, however, found that ferric chloride (sesqui-chloride of iron) acted well, and Scherer recommends the use of a neutral sulphate of iron.

In the last years an extensive use of alum has been made in the many processes of purifying water, sewage, etc. It is not improbable that aside from its effect in precipitating matter mechanically by envelopment with the precipitating basic aluminic sulphate, the alum exerts a distinct coagulative action on the albuminous substances in the water, rendering them insoluble, and thus causing their precipitation; perhaps the same, or similar effect, that alum produces in the tawing of leather. One of the most prominent applications of alum at present is in the Hyatt filter. By the addition of a minute amount of alum, water is rendered capable of a most perfect mechanical filtration.

The fact that alum is cheap and can be obtained in quite a pure state at any drug store, places it within the reach of every one. Its sharp taste precludes the possibility of its being swallowed by mistake.

But even should it be swallowed by mistake, no great harm would be likely to ensue, unless a large amount were taken. In medical treatment as high as 30 grains are given in a single dose, and this may be repeated four times per day. If it can be proven that alum not only clarifies a water, but also removes from it disease germs and ptomäines, its use will prove of incalculable value to the human race, for facts begin to indicate that a vast number of diseases are communicated through drinking-water.

The investigation of the effects of alum on drinking water falls under the several heads—

I. Clarification of the water by settling.
II. Clarification of the water by filtration.
III. Use of water clarified by alum in manufacturing.
IV. Removal of disease germs.
V. Removal of ptomäines.
VI. Removal of organic matter.

The investigation must needs be both chemical and biological. Only the first and part of the second cases have so far been examined

I. THE EFFECT OF ALUM IN CLARIFYING WATER BY SETTLING.

It is evident that to obtain practical results in the clarification of water by alum, it must be added in such small amounts as to leave no unnecessary excess, and that neither taste nor physiological action should be imparted to the water. At the time of our experiments (January, 1885,) the New Brunswick city water was quite turbid from clayey and other matters, so that we were able to obtain some very reliable results.

The amount of alum used in the experiments of Jennet seems to be unnecessarily high, in case the water is to be drunk. Water was treated with the amount of alum recommended by Jennet (23.3 grains to the gallon), but no perfect settling was obtained under six hours or more; in some cases not under twelve hours. The water thus treated had no perceptible taste of alum, but it gave a decided reaction for alumina when treated with ammonia, showing that the water contained a certain amount of free alum. While the amount is evidently too small to produce any physiological effect, there seems to be no necessity to use such an excess.

To determine the effect of alum as a precipitating agent, tall cylinders were filled with water and a solution of alum was added, the whole well mixed and allowed to stand. It was found that in varying lengths of time, depending on the amount of alum used, a gelatinous precipitate settled out, and the water above it became perfectly clear. On adding a relatively large amount of alum and mixing, the coagulation and separation of the precipitate is at once visible, the water appearing by careful examination to be filled with gelatinous particles. The amount of alum necessary for the precipitation of a water will, of course, depend on the amounts of impurity present, but in the present case, which may be taken as a typical one, we found that 0.02 grams of water to a liter of water (1.2 grains to a gallon) caused the separation and settling of the impurities, so that the supernatant water could be poured off. This amount of alum was shown by numerous experiments to be about the practical limit. The complete settling took place as a rule in not less, and usually more, than two days. It is evident that the amount of alum thus added is too slight to be perceptible to the taste, and can exert no physiological action. We were unable to detect the slightest taste or change in the water so treated.

Still smaller amounts of alum will produce a precipitate after longer standing. Sixty liters of the city water were treated with two grams of alum (this was about 31 grains to 16 gallons) and allowed to stand. After forty-eight hours the precipitation seemed complete, and the water was perfectly clear, while the bottom of the vessel was covered with a brownish, slimy deposit. This substance was collected, dried and analyzed. It gave—

Carbon	16.50 per cent.
Hydrogen	2.02 "
Nitrogen	0.77 "

It is evident from this analysis, that a large amount of the organic matter has been removed from the water by the alum treatment.

On incineration, it yielded 59.28 per cent. of ash, which contained silica and alumina in relatively small amounts, oxide of iron in large amounts, and a considerable quantity of phosphoric acid.

To determine if there was free alum in the water, a sample of the clear water, filtered off from the precipitate produced by the alum, was made slightly alkaline with ammonia and warmed for some time.

Only the merest traces of an alumina reaction could be obtained, and, in fact, in some cases, it was doubtful if a reaction was observable. To prove that no more matter could be precipitated by the addition of a greater amount of alum, samples of the clean filtered water were treated with more alum, but there was in no case any indication of further precipitation on standing.

We consider it, then, established that, by the addition of two grains of alum to the gallon, or half an ounce to one hundred gallons, water can be clarified by standing, and that neither taste nor physiological properties will be imparted to it by this treatment. By increasing the amount of alum, the time required for the separation and settling can be diminished, and *vice versa*, by diminishing the amount of alum added, a greater time will be required for the clarification.

This method is particularly adapted to the clarification of large volumes of water, where filtration is not practical. The cleared water can be racked off to as low a level as possible, after which the sediment should be washed out and the receptacle cleansed by a free use of water.

II. THE EFFECT OF ALUM IN CLARIFYING WATER BY FILTRATION.

In order to test the clarification of water by filtration after addition of alum, the New Brunswick city water was again made the subject of our experiments. It was found that the suspended clayey matters were so fine that the best varieties of filtering papers were unable to remove them. Even when several layers of heavy Schleicher and Schüll paper were used, a very large portion of the suspended matters passed through. This, however, is not surprising, since it is well known that the mineral matters suspended in water are of a remarkable degree of fineness. Thus the water of the river Rhine, near Bonn, cannot be clarified by simple filtration, and takes four months to settle. The addition of certain chemicals aids the filtration of suspended matters in some cases, but it does not always entirely remove them. Calcium chloride and other salts are recommended as effective agents in aiding the removal of suspended matters, but in the case of the New Brunswick water, at least, they have no apparent action. The following substances were found to have no effect in aiding the filtration of the water: Sodium salts—chloride, carbonate, nitrate, acid carbonate, hydrogen phosphate, acid sulphite, ammonium phosphate, sulphate, biborate, tungstate, acetate; potassium salts—hydroxide, chloride, bromide, iodide, acetate, phosphate; ammonium salts—chloride, sulphate, nitrate, acetate; calcium salts—oxide, chloride, sulphate, nitrate. Zinc sulphate and ferrous sulphate (copperas) had no action. Acid sulphate of potassium and of sodium had a slight clearing action. Acetate and chloride of zinc had an apparent action. Ferric chloride (perchloride of iron) cleared perfectly, as also did the nitrate and sulphate of aluminium.

By the addition of a small amount of alum to water, it can be filtered through ordinary filter paper without difficulty, and yields a brilliantly clear filtrate, in which there is no trace of suspended matter. In our experiments, a solution of alum was added to the water, the whole well mixed by stirring or shaking, and then filtered after standing from one to fifteen minutes. So far as we were able to determine, the coagulative and precipitative action of the alum is immediate upon thorough mixture, and hence it is not necessary to allow the mixture to stand before filtration, but it can be filtered immediately after mixing.

To determine the amount of alum necessary to precipitate this water, alum was added in decreasing amounts to samples of water, which were then filtered through Schleicher and Schüll paper. In this way we found that the minimum limit was about .02 grams of alum to one liter (1.16 grains to one gallon). Beyond that point the action of the alum began to be doubtful, and the water, although clarified by filtration, was not wholly clear. To be sure of complete clarification, we took double this amount—.04 grams to one liter (2.3 grains to one gallon)—as a standard calculated to give certain results. This amount can be doubled or trebled without fear of any harmful results, but there is no use of adding any more alum than is sufficient to do the work. The determination of the amount of solids removed from the water by the clarification with alum had not yet been finished.

We consider it, then, as established that, by the addition of two grains of alum to the gallon of water, or half an ounce to the hundred gallons, water can be rendered capable of immediate clarification by filtration. The clear water obtained by filtration, after adding this amount of alum, contains no appreciable amount of free alum, and, in fact, in the majority of cases, ordinary tests fail to reveal its presence.

While the clarification of water by standing is very successful and well adapted to the treatment of large volumes of water, especially when time is not an element of importance, the case will very frequently occur that a relatively small amount of water is to be purified in a short time. In such a case not clarification alone is demanded, but it is necessary that the operation should take as short a time as possible. Again, in order to make this method of clarification practical for domestic use, the operation of filtration must be made extremely simple. No complicated or expensive apparatus should be used, but the filter must be made out of the simplest articles, such as can be found in every household. In this field there is an opportunity for the exercise of considerable mechanical ingenuity, and when the principles of the filtration are understood, and more is known about the different kinds of filtering materials, there will doubtless be many forms of house-filters devised out of the odds and ends which may be at hand.

It is not a difficult matter to get up a large filter that shall clarify many hundred gallons of water a day in an effective manner. Such apparatus already exists and is used in manufacturing establishments. In their construction, many points, such, for instance, as the cleansing of the filtering material, have been brought to a high grade of perfection. The difficulty lies in devising some form of simple and cheap filter which will filter a small amount of water as effectively as a relatively large amount, which will be always ready, will always work, will be so simple that any one can understand its operation, can be easily made, not easily broken, but easily repaired if broken, and which will not entail much extra work in order to get a clarified water. The filtering material must be cheap, easily obtainable, easily prepared, capable of being cleansed when clogged by use, or so cheap that it can be thrown away and replaced by new without appreciable expense.

It is evident that the shape, size and arrangement of the filtering apparatus will depend very largely on the kind of filtering material used. Hence we began by experimenting on filtering media. The glass funnel and carefully-folded paper will be of but little service outside of the laboratory. But in cases of great importance, such as the preparation of water for the sick, this method is worthy of attention.

In the large Hyatt filters a mixture of coarsely-ground coke and sand is used, and does most admirable and effective work. Granulated bone charcoal also makes a most excellent filtering bed. The most practical material for domestic use, however, so far as we have been able to ascertain, is cotton. Cotton batting can be bought in the shops for about ten cents a pound, and a pound of it will go a long way in filtering. It makes a coherent filtering layer, and when clogged by use can be cleansed by boiling up in water and rinsing, or, as it is so cheap, can perhaps as well be thrown away and replaced by new.

The simplest form of filter for filtering considerable amounts of water is a tube, one end of which is stuffed with cotton. A drain pipe is the best material, since it can be so easily cleansed. The plug of cotton should be from two to three inches thick, and may be held in place by a round piece of wood fitting into the bottom of the drain pipe at its shoulder, and secured by any suitable means. The piece of wood should be perforated to allow the water to pass through. The shoulder of the pipe may be set in a circular channel cut in a piece of board, and by means of a central channel the water may be made to run off at a point of delivery. In our next report we shall present plans of simple filters, and the results of our experiments with them.

The most practical form of filter for household use, and one that will easily filter a pitcher full of water in a short space of time, can be made out of a bottle. The best form is the long kind in which sweet oil is sold, although almost any kind of glass or earthenware bottle will answer. The bottom of the bottle is cracked off, and the sharp edge removed by rasping with a file. The cracking can be done by tying a thin, soft string, soaked in turpentine, around the place where it is intended to crack, leaving as small a knot as possible, then setting fire to the turpentine, holding the bottle bottom up. After allowing the oil to burn for an instant, the end of the bottle is placed quickly in cold water, when, if the operation has been rightly conducted, an even crack will be produced, and the bottom of the bottle will come off easily.

A layer of cotton is now placed in the bottle. The cotton must be worked in water, preferably warm water, in order to remove the adhering air, and to wet it well. A wad of the wet cotton is dropped into the bottle and covers the mouth of the neck. Other pieces are dropped in, care being taken to build the layer up evenly, and to add the cotton in rather small pieces. After dropping them in, they should be pressed down and arranged by means of a rod. In this way a layer is made which should be from two to three inches thick. It should not be pressed down too tightly, else it may filter too slowly; neither should it be too light, or water may form channels through it.

After a little use the plug generally adapts itself. Particular care should be taken to be sure that the cotton is snug against both sides, since the water is liable to escape there. The plugs, however, are easy to make, and a few attempts will soon teach one all the necessary manipulations.

This bottle filter can be suspended or supported in any convenient way. Perhaps the simplest support is a block of wood having an augur hole bored through the center, and the edges of the hole reamed out. In this hole the bottle sits securely, and the bevel of the hole catches the shoulder of the bottle, thus holding it upright. To use this filter, it is only necessary to pour the water, which has been previously mixed with the right amount of alum, into it, when the clear water will run in a considerable stream from the bottom, and can be caught in any convenient receptacle. It is well to throw away the first tumblerful that runs through, if the plug is a new one, as a little sediment will pass through at first, but this soon stops. It is also advisable to keep the bottle nearly full while filtering, as this hastens filtration.

The mixing of the water with the alum previous to the filtration should be done in a separate receptacle. The only requisite here is that the vessel in which the mixing is done must be clean. A pail, jug, can, or any other vessel used in the kitchen will do. It is well to have the pail, or can, marked on the inside with scratches so as to be able without difficulty to judge how much water there is in it, since the amount of alum should be added in about the right proportions. The eye gets very accurate in judging the volume after a little practice, but it is better, and just as easy, to be accurate. A clean tin can of two to four gallons capacity is a good size, and, if possible, should not be used for any other purpose than for the drinking water. It should be kept scrupulously clean, and after each use should be washed out and dried. It can be graduated by pouring into it a gallon of water and marking with a file, or other sharp point, a scratch just at the level of the water. Then another gallon is poured in and its level also marked. In this way a graduation is easily made which is sufficiently accurate for all the purposes here intended. As a rule, a can of four gallon capacity will be found quite large enough to filter the water used by a family of average size. The necessary amount of the alum solution is added to the water, the whole well mixed by stirring, and then poured into the filter. Here, again, one or two points should be observed. The mixing is best done with a long-handled spoon. A very practical stirrer is a small cake-turner, for by means of its flat end, a most thorough mixing can be effected. This mixer should not be used for any other purpose than to mix the water. Experience shows that if the vessels used for mixing or holding the water are not kept perfectly clean, that the water may acquire a taste, and this will be laid to the process instead of to lack of care. To facilitate the pouring into the filter, it is well to have the can provided with a mouth or spout. In fact, there is no form of can better than the regular garden watering-pot, with its long spout.

The solution of alum is made as follows: Dissolve half an ounce of alum in a cup of boiling water, and, when it is all dissolved, pour into a quart measure and fill to a quart with cold water. (This solution should be kept in a bottle labeled "ALUM.") Fifty-four drops of this solution contain 2.3 grains of alum, which is the amount to be added to one gallon of water. The old-fashioned teaspoon holds about forty drops; the new spoons, however, hold about seventy drops. Hence, a modern teaspoon, scant full, will be about the right amount to add to every gallon of water to be filtered. No harm will be done if by mistake two teaspoonsful are added; in fact, ten teaspoonsful would have to be added to bring the amount of alum up to the figure recommended by Jennet (*loc. cit.*) A more satisfactory method will be to procure a small measuring glass. One fluid drachm will then be the right amount. It will be found, without doubt, that the amount required for some waters will be even less than that suggested above. We would suggest, therefore, that those who use this method of clarification, determine for themselves by experiment how little of the solution is required to make the water they use run through the filter perfectly bright and clear.

XII.

STATISTICS OF IRON AND ZINC ORES.

IRON ORE.

The output of the iron mines of the State for the year 1884, as shown by the shipments of iron ore from stations in the State and the amounts used at furnaces which do not come in the tonnage of the railroad lines, aggregated 393,710 tons—a deficit of 127,706 tons as compared with the production of 1883. For the convenience of reference the statistics of iron ore mined in the State for the years 1870–1884, inclusive, are here inserted in a tabular form. Estimates and U. S. census figures at intervals back to 1790 are also given at the head of the column.

1790	10,000 tons	Morse's estimate.
1830	20,000 tons	Gordon's Gazetteer.
1855	100,000 tons	Dr. Kitchell's estimate.
1860	164,900 tons	U. S. census.
1864	226,000 tons	Annual Report State Geologist.
1867	275,067 tons	Annual Report State Geologist.
1870	362,636 tons	U. S. census.
1871	450,000 tons	Annual Report State Geologist.
1872	600,000 tons	Annual Report State Geologist.
1873	665,000 tons	Annual Report State Geologist.
1874	525,000 tons	Annual Report State Geologist.
1875	390,000 tons	Annual Report State Geologist.
1876	285,000 tons*	
1877	315,000 tons*	
1878	409,674 tons	Annual Report State Geologist.
1879	488,028 tons	Annual Report State Geologist.
1880	745,000 tons	Annual Report State Geologist.
1881	737,052 tons	Annual Report State Geologist.
1882	932,762 tons	Annual Report State Geologist.
1883	521,416 tons	Annual Report State Geologist.
1884	393,710 tons	Annual Report State Geologist.

* From statistics collected later.

This tabular statement shows that from 1870 to 1874 there was a gradual and steady increase in the annual production. The financial depression in the latter part of 1873 marked a turn in the rate of production, and the lowest output for the decade was reached in 1876. The product for 1877 was slightly in excess of that of 1876, and from that year onward there was a gradual rise to the boom of 1879, which showed itself in the large increase in 1880. The maximum was attained in 1882. The decline since has been marked.

ZINC ORE.

The product of the zinc mines for the year 1884, as shown by the shipments over the transporting lines, was 40,094 tons.

XIII.

PUBLICATIONS OF THE SURVEY.

The ANNUAL REPORTS OF THE STATE GEOLOGIST are printed as part of the legislative documents of the State. They are largely distributed by the members of the Legislature. Extra copies are distributed by the members of the Board of Managers of the Geological Survey, and the State Geologist also distributes copies to libraries, institutions of learning, and, as far as possible, to persons interested in such work. A list is kept of those to whom distribution is made regularly. The extra copies of the reports of most of preceding years are all distributed.

The REPORT OF THE FIRE AND POTTERS' CLAYS OF NEW JERSEY, with a map of the clay district of Middlesex county, published in 1878, has been very widely distributed. There are copies still on hand for distribution.

A PRELIMINARY CATALOGUE OF THE FLORA OF NEW JERSEY, prepared by N. L. Britton, Ph.D., was printed in 1881, and distributed to botanists for their remarks, corrections and additions. A great many of the plants have been noticed in only a single place in the State. By the circulation of this catalogue among botanists, it is hoped that many new localities of rare plants will be discovered, and the list thoroughly revised. The catalogues are to be returned after two or more seasons, and the notes in them used in making out a more perfect catalogue, for general circulation throughout the State. Only 600 copies were printed, and these have already been placed in the hands of working botanists, and much has already been accomplished in its revision. The work commends itself to all lovers of botanical science, and we are promised their hearty co-operation in completing the revised edition.

A TOPOGRAPHICAL MAP OF A PART OF NORTHERN NEW JERSEY, on a scale of one mile to an inch, is printed, and has been distributed to some extent. In addition to the delineation of boundaries, streams, roads and geographical matter, it has on it contour lines of level, so that the elevations of the surface above mean-tide are accurately marked on all parts of it. This map has been very generally approved, and is in demand for laying out drains, ditches, water-works, roads and railroads, and for selection of building-sites, and as a study for drives, bicycle excursions, etc.

THE ATLAS OF NEW JERSEY is now in course of preparation, and several sheets are done. These sheets are each 27 by 37 inches, including margin, and are intended to fold once across, making the leaves of the atlas 18½ by 27 inches. The completed work will be made up of seventeen of these maps, on a scale of one mile to the inch, and one map of the whole State, on a scale of 5 miles to the inch. The location and number of each map is given on the reference map, on page 11 of this report, and is printed on the paper cover of the atlas. Numbers 3, 4 and 7 are done, and numbers 2, 6 and 16 will be ready in March, 1885. The other numbers will be issued, probably, in 1886, '87 and '88.

GEOLOGICAL MAP OF NEW JERSEY. Scale, six miles to an inch. The improvements going forward in the State call for a revision of our map very often. The one which was printed with the annual report of 1882, and was corrected up to that date, had some corrections in railroads, some minor improvements in the geological coloring, and much was added in new places along the sea-shore, and the life-saving stations were all located.

The results of the Survey are intended for the benefit of the citizens of the State, and the Board of Managers have charge of and direct the distributions of its collections, reports, &c. The addresses of the members of the Board are given on page 3 of this report, and application made for publications to them, or through them to the State Geologist, will be received and given due attention.

XIV.
EXPENSES.

The expenses of the Survey are kept strictly within the annual appropriation of $8,000, and all bills and liabilities incurred up to date are paid in full.

XV.
PERSONS EMPLOYED.

My own time has been occupied with the business of the Survey, providing the men and means for carrying forward the work steadily and efficiently. I have been much interested in helping to carry forward various works for applying geological science to practical and useful purposes.

Prof. John C. Smock, Assistant Geologist, has been occupied in the Survey work only a part of the year. His work included a re-examination of the Green Pond mountain rocks and studies of the geological structure of our Archaean rocks. He has prepared the portion of the report relating to both those series of rocks, and that upon the iron mines and mining industries.

In the chemical department no chemist has been steadily employed, but needed chemical investigations have been made by Profs. Austen and Wilber, Professors of Chemistry in Rutgers Scientific School.

Prof. J. S. Newberry, of Columbia College, New York City, has still in hand his monograph of the fossil fishes of our Triassic sandstone and that of the Triassic and Cretaceous Flora.

Prof. R. P. Whitfield, of the American Museum of Natural History, is making progress with his work of figuring and describing the invertebrate fossils of the Cretaceous formation of New Jersey. The portion on the Lamellibranchs and Brachiopods is in the hands of the lithographer, and will soon be issued.

Dr. N. L. Britton is still engaged in revising, correcting and improving the Catalogue of Plants of New Jersey, and it is expected that he will soon have entered upon the list very nearly all the plants growing in the State. He spent some time last summer in the Survey collecting specimens of needed Cretaceous fossils and studying their geological relations.

George E. Jenkins, B.S., was engaged as assistant in collecting the statistics of the iron mines and mining industries.

ERRATA.

Page 11, line 8, for "63,560" read "63,360."

Page 74, line 12 from bottom, for "Herry" read "Sherred."

Page 83, line 19, for "Grethaway" read "Trethaway."

Page 85, line 25, for "Tontring" read "Tonking."

Page 93, line 16, add "1883, pp. 120–122."

XVI.

WORK TO BE DONE.

The work of the Survey is steadily advancing. The construction of an accurate topographical map of the State is well advanced. As far as done, it meets with the hearty approval of all who have seen it; and since it was begun, a number of other States have organized surveys for similar maps of their territory. The work in our State is about three-fifths done, and, with the force now employed, will be completed in two years more.

The work for the whole State is engraved on seventeen maps of one inch to the mile each. The location of these, with their numbers, can be seen on the small index map on page 11.

Nos. 3, 4 and 7 were issued last March. Nos. 2, 6 and 16 are being printed, and will be ready for distribution in February or March. The surveys for Nos. 1, 9, 13 and 17 are done, and the maps will be ready for distribution by the end of 1885.

The topographic surveys follow the geodetic surveys, using the geographical positions determined in those surveys, and in this way our maps can be properly adjusted in their true positions and relations. This will carry the work forward, probably, in the following order, viz., Nos. 8, 11, 12, 5, 10, 14 and 15.

The geological structure of our Archaean and Paleozoic rocks, and their mineral wealth, needs much study to put it in proper form for general use, and this work must now be pursued with all the means which can be devoted to it.

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